

GV
776
C22
R47
1976
IGSL
UCB

IMPACT OF INCREASED BOAT TRAFFIC IN POINT POTRERO REACH

May, 1976

**PREPARED FOR
CITY OF RICHMOND
CALIFORNIA**

KOEBIG , INC.

K **KOEBIG, INC.** ENGINEERING • ARCHITECTURE • PLANNING
ENVIRONMENTAL MANAGEMENT
POST OFFICE BOX 671, 1053 SUNSET BOULEVARD,
LOS ANGELES, CA. 90053 • (213) 629-3182 TELEX 67-202

May 17, 1976

City of Richmond
City Hall
Richmond, California 94804

Attention: Mr. Ralph E. Mohagen
Office Engineer
Public Works Department

Dear Mr. Mohagen:

FINAL REPORT, IMPACT OF INCREASED BOAT TRAFFIC IN POINT POTRERO REACH

We are pleased to transmit this report, "Impact of Increased Boat Traffic in Point Potrero Reach." We believe this report will provide valuable assistance to the staff of City of Richmond in evaluating the adequacy of its navigational channels for future boat traffic.

This was a most interesting study and we wish to thank and acknowledge the support received from the staff of your City.

Very truly yours,

KOEBIG, INC.

Donald E. Hughes

Donald E. Hughes
Project Manager

Enclosure

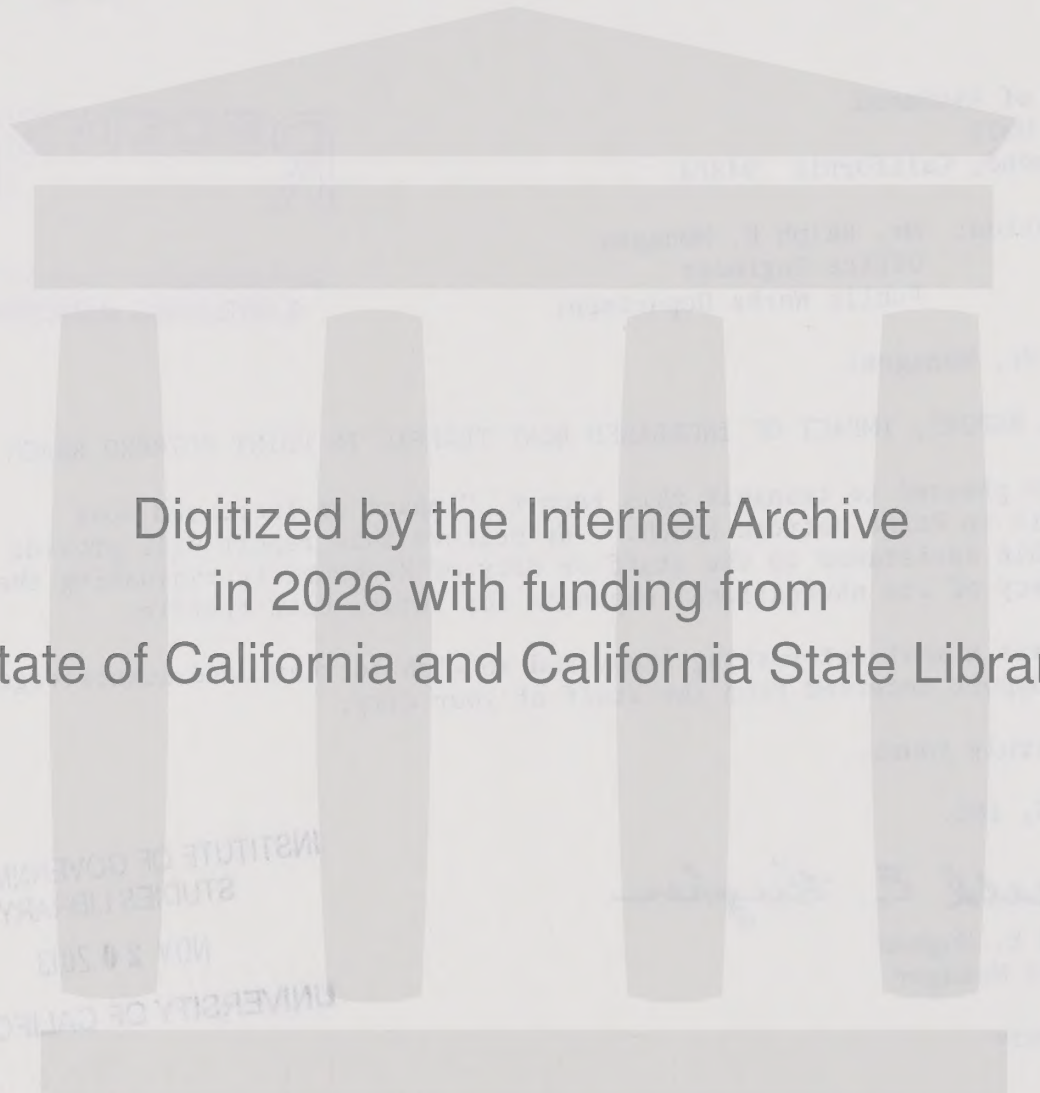
GV776
C22
R47
1976
IGSL
ULB

R. P. LUNDIN P.E.
H. O. DAIGH A.M.A.
N. W. WEINBERG P.E.
D. A. COTTON A.I.P.
F. P. DINGER A.I.A.
D. M. HALL P.E.

RECEIVED
JUN 14 1976

SAN FRANCISCO BAY CONSERVATION
& DEVELOPMENT COMMISSION

INSTITUTE OF GOVERNMENTAL
STUDIES LIBRARY
NOV 20 2013
UNIVERSITY OF CALIFORNIA



Digitized by the Internet Archive
in 2026 with funding from
State of California and California State Library

<https://archive.org/details/C113908831>

IMPACT OF INCREASED BOAT TRAFFIC
IN POINT POTRERO REACH

Prepared For
City of Richmond
California

KOEBIG, INC.
Los Angeles, California
May, 1976

TABLE OF CONTENTS

<u>Section</u>	<u>Page No.</u>
PURPOSE OF REPORT	1
EXISTING CONDITIONS	1
Study Area	1
Point Potrero Reach and Point Potrero Turn	2
Climate	2
DEEP DRAFT VESSEL AND BARGE TRAFFIC	6
SMALL CRAFT TRAFFIC	7
Introduction	7
Methodology	7
Traffic Data From Other Marinas	8
Small Craft Traffic at Richmond	13
ADEQUACY OF CHANNELS	16
Introduction	16
Analytical Determination of Channel Adequacy	16
Case Studies	19
Alternate Channels for Richmond Harbor	20
CONCLUSIONS AND RECOMMENDATIONS	21
BIBLIOGRAPHY	23

LIST OF PLATES

<u>Plate</u>	<u>Title</u>	<u>Following Page No.</u>
1	Vicinity Map	1
2	Existing Conditions	2
3	Alamitos Bay, Long Beach, California, Boat Traffic - Entrance Channel, Friday, August 30, 1974.	9
4	Alamitos Bay, Long Beach, California, Boat Traffic - Entrance Channel, Saturday, August 31, 1974.	9
5	Alamitos Bay, Long Beach, California, Boat Traffic - Entrance Channel, Sunday, September 1, 1974.	9
6	Alamitos Bay, Long Beach, California, Boat Traffic - Entrance Channel, Monday, September 2, 1976 (Labor Day).	9
7	Projected Small Craft Traffic at Point Potrero Turn - 1976, Richmond, California.	16
8	Projected Small Craft Traffic in Point Potrero Reach - 1976, Richmond, California.	16
9	Projected Small Craft Traffic at Point Potrero Turn - 1979, Richmond, California.	16
10	Projected Small Craft Traffic in Point Potrero Reach - 1979, Richmond, California	16
11	Projected Small Craft Traffic at Point Potrero Turn - 1983, Richmond, California	16
12	Projected Small Craft Traffic in Point Potrero Reach - 1983, Richmond, California.	16
13	Projected Small Craft Traffic at Point Potrero Turn - 1986, Richmond, California.	16
14	Projected Small Craft Traffic in Point Potrero Reach - 1986, Richmond, California.	16
15	Projected Small Craft Traffic at Point Potrero Turn - 1989, Richmond, California.	16

<u>Plate</u>	<u>Title</u>	<u>Following Page No.</u>
16	Projected Small Craft Traffic in Point Potrero Reach - 1989, Richmond, California.	16
17	Richmond Harbor, Possible Channel, Alternate A	20
18	Richmond Harbor, Possible Channel, Alternate B	20

LIST OF TABLES

<u>Table</u>		<u>Page No.</u>
1	Wind Direction and Velocity Data, Standard Oil Refinery, Richmond, California, June, 1947 - June, 1948.	3
2	Number of Vessel Trips to Port of Richmond, Year 2030.	6
3	Average Daily Generation Rates and Peak Hour Factors, Labor Day Weekend, 1974, Alamitos Bay.	9
4	Average Daily Generation Rates and Peak Hour Factors, 1967-71, Newport Bay.	10
5	Average Daily Generation Rates and Peak Hour Factors, 1963-69, Newport Bay.	12
6	Average Daily Generation Rates, Huntington Harbour, 1975.	13
7	Average Daily Generation Rates and Peak Hour Factors for Use in Projecting Boat Traffic at Richmond.	14
8	Slips in Richmond Area.	14
9	Small Craft Traffic at Point Potrero Turn and Point Potrero Reach on Typical Summer Sunday.	15

PURPOSE OF REPORT

The City of Richmond proposes to develop a large marina, consisting of 1,750 slips and a four-lane launch ramp, in the Inner Harbor Basin as a part of the Redevelopment Plan for Project 11-A. In addition, new container terminal berths are being added to the Port of Richmond. The purpose of this report is to:

1. Determine the level of boat traffic that will ultimately develop from these proposals.
2. Determine the adequacy of the existing channels, particularly Point Potrero Turn and Point Potrero Reach, to accept the additional boat traffic.
3. Evaluate the impact of this increased boat traffic on boating safety.
4. Make recommendations as to any channel improvements that may be required.

This report will provide input to the Corps of Engineers which is preparing a project report for deepening existing deep-draft channels and to a City of Richmond-BCDC committee charged with preparing amendments to the Richmond General Plan and the BCDC Bay Plan.

EXISTING CONDITIONS

Study Area

Richmond is located on the eastern shore of San Francisco Bay, approximately nine miles northeast of the Golden Gate Bridge. The Port of Richmond occupies the southern Richmond waterfront. The area under study in this report is shown on Plate 1, Vicinity Map.

Harbor facilities at the Port of Richmond include an outer harbor approximately five miles in length between Point San Pablo and Point Richmond; an inner harbor nearly four miles in length, extending from Point Richmond to and around Point Potrero, and thence to the end of the Santa Fe Channel, and also to the Inner Harbor Basin via the Ford Channel. The shore and channel (Point Potrero Reach) between Point Richmond and Point Potrero are protected by a 10,000-foot long rubble-mound rock training wall extending westerly from Brooks Island.

This report focuses on the impact of additional small craft traffic on the existing boat traffic. At the end of the training wall or Point Richmond the adjoining depths to the harbor channel are in excess of 12 feet, hence small craft are not confined by the channel limits west of Point Richmond. Therefore, the study area is confined to Point Potrero Reach and Point Potrero Turn.



KOEBIG, INC. ENGINEERING-ARCHITECTURE-PLANNING LOS ANGELES, CALIFORNIA	RICHMOND HARBOR VICINITY MAP
---	---

Point Potrero Reach and Point Potrero Turn

Plate 2, Existing Conditions, shows Point Potrero Reach and Point Potrero Turn. Point Potrero Reach has a width of 500 feet, and flares to about 600 feet at Point Potrero Turn. Point Potrero Turn is a sharp turn and has a varying width of 500 - 1150 feet. The project depth for Point Potrero Reach and Point Potrero Turn is 35 feet. The Corps of Engineers is studying alternatives to dredge deeper harbor channels and a turning basin in the Ford Channel adjacent to the entrance of the Inner Harbor Basin to accommodate the needs of the third generation containerships.

The Coast Guard has provided flashing light beacons and day boards on single piles along both sides of the channel. These piles are set back from the toe of slope. The piles are roughly 60 feet in length and extend to approximately elevation +15 mean lower low water datum.

About 500 feet of shallow Bay bottom, generally 2 to 5 feet in depth, exists between the southerly side of Point Potrero Reach and the U. S. Pierhead and Bulkhead Line near the training wall. If needed, this area could be used for channel improvements in the future.

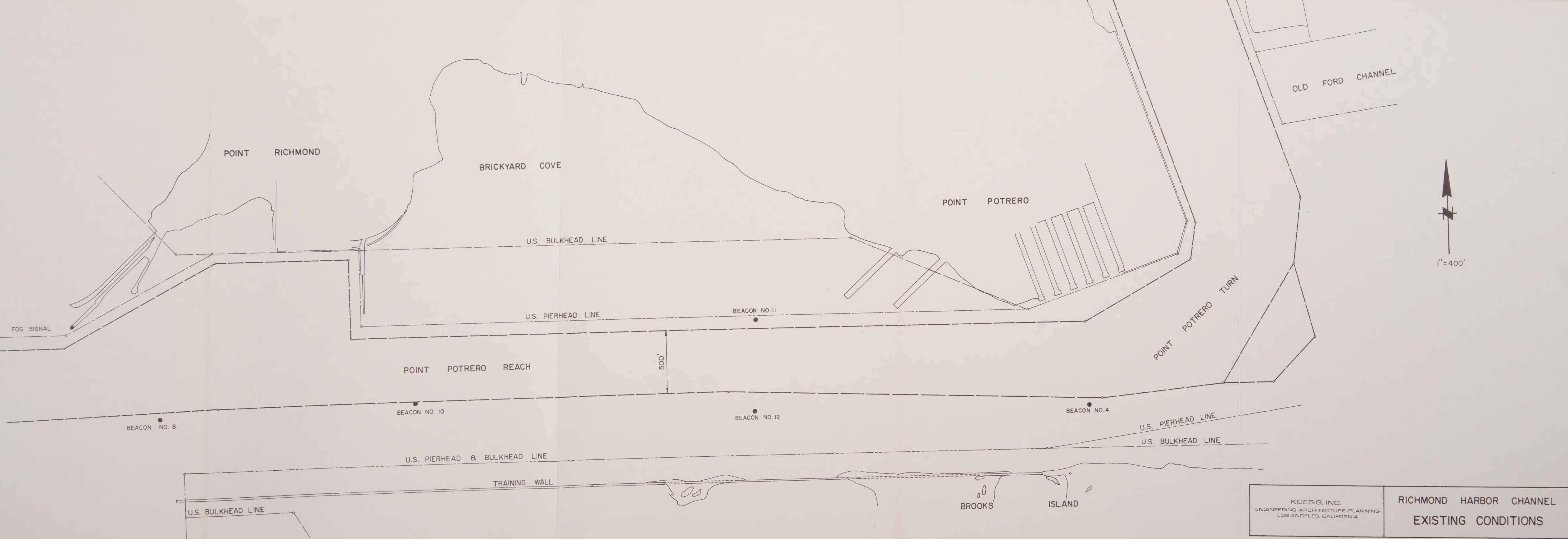
Climate

The climate at Richmond is typical of other communities on San Francisco Bay. Temperatures are classified as mild, ranging from a mean low of 43 degrees in winter to a mean high of 74 degrees in September. The warmest months are in early spring and fall, with the summers cooled by the presence of fog. Sunshine occurs an average of approximately two-thirds of the possible daylight hours. Rainfall averages about 22.3 inches per year, with most of it falling between November and March.

In a study of small craft boat traffic, and particularly in this study where shallow-draft and deep-draft vessels are in potential conflict, it is important to research certain climatological factors. These include wind, fog and currents.

Wind. The prevailing wind most of the year is from the south and southwest. The winds prevail from the north and northwest from November through January.

Two sets of wind data were available for this study. The data was collected in 1947-48 at the Standard Oil Refinery near the Long Wharf, which is located near the Richmond-San Rafael Bridge, and the University of California Field Station, which is located just easterly of the Inner Harbor Basin.



The data from the Standard Oil Refinery was collected from June, 1947 to June, 1948. Below is a tabulation of the wind direction and velocity data and a wind rose.

Table 1
WIND DIRECTION AND VELOCITY DATA
STANDARD OIL REFINERY, RICHMOND, CALIFORNIA
JUNE, 1947 - JUNE, 1948

MONTH	DIRECTION (%)								VELOCITY (%) (M.P.H.)			
	N	NE	E	SE	S	SW	W	NW	CALM	4-10	10-20	ABOVE 20
June	6.2	0.2	0.3	8.9	45.2	27.2	8.5	3.5	2.4	67.0	26.7	3.9
July	0.0	0.2	0.1	17.7	48.8	17.2	15.0	1.0	1.1	71.1	27.1	0.7
August	1.2	0.3	0.3	4.5	45.9	41.4	6.1	0.3	0.7	76.3	21.1	1.9
September	2.5	1.8	1.7	17.1	50.2	21.3	5.4	0.0	0.0	81.3	18.7	0.0
October	9.0	4.9	4.0	12.1	30.8	30.9	5.1	3.2	4.5	67.8	23.9	3.8
November	34.7	15.6	5.0	10.6	11.3	11.1	6.1	5.6	12.1	67.9	17.6	2.4
December	28.0	24.5	3.6	11.0	17.9	7.5	4.4	3.1	1.0	82.2	15.7	1.1
January	44.0	18.4	6.5	3.1	13.5	8.1	1.0	0.4	4.5	85.2	8.3	2.0
February	16.2	15.9	5.3	11.8	17.7	15.3	12.0	5.8	13.7	58.8	24.6	2.9
March	8.9	12.2	1.7	4.6	17.7	30.6	19.0	5.3	11.1	52.7	32.5	3.7
April	3.1	2.2	1.8	5.3	23.2	39.7	20.0	4.7	8.3	48.2	37.4	6.1
May	4.1	1.1	0.7	3.4	29.3	30.9	26.5	3.8	6.2	53.9	38.4	1.5
TOTAL	13.3	8.2	2.6	9.6	29.2	23.3	10.8	3.0	5.7	67.2	24.5	2.6

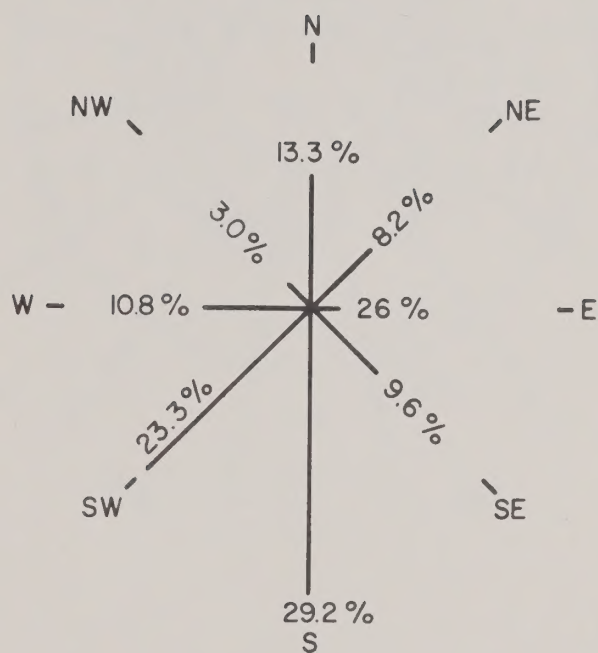


Figure 1
WIND ROSE, STANDARD OIL REFINERY
RICHMOND, CALIFORNIA
JUNE, 1947 - JUNE, 1948

The wind data from the University of California Field Station, Richmond, California was apparently collected between 1947-1948. The data is presented in the following wind rose.

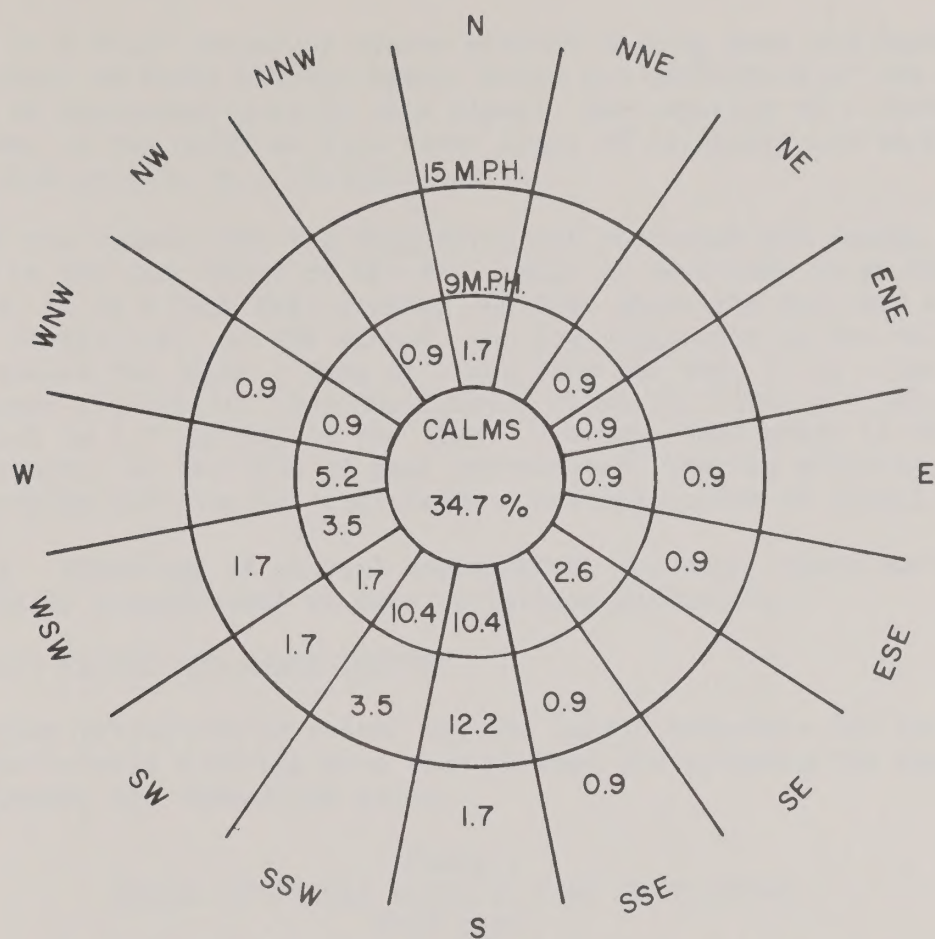


Figure 2
WIND ROSE, UNIVERSITY OF CALIFORNIA FIELD STATION
RICHMOND, CALIFORNIA
1948

The two sets of data differ remarkably in the percent of calm wind (0-4 mph). The Standard Oil data shows 5.7 percent calms for the year while the U. C. Field Station wind rose shows 34.7 percent calms. It is unknown what period of time is represented by the U. C. Field Station wind rose. The hills between Point Potrero and Point Richmond probably account for part of this difference by acting as a buffer to the Inner Harbor Basin area.

The Standard Oil Refinery data is extremely valuable, because it shows a monthly breakdown of wind direction. It is important to note that in the summer months, June - September, which represents the bulk of the recreational boating system, the wind blew from the south and southwest 74 percent of the time. This prevailing wind direction permits sailboats

to sail on a reach (straight course without tacking back and forth across the channel) in Point Potrero Reach, hence the derivation of the name. As will be discussed later in this report, the capacity of a channel is much less, on the order of five times less, if sailboats are tacking rather than sailing on a straight course.

Fog. In the summer, the fog originates off the coast and pushes towards the Bay in the late hours of the day. When it does come in as far as Richmond, it is a high fog, perhaps 200 feet above the Bay, and does not obscure visibility. In the winter, the fog originates in the valley and pushes toward the coast. When it comes into the Bay, it is a low fog and can obscure visibility. One publication shows 324 hours per year of dense fog, which is 3.7 percent of the time. The important point is that in the summer months, at the time of peak recreational boating activity, fog is not a problem and does not constitute a boating hazard of itself.

Currents. According to pilots' experiences, currents, winds and waves are normally insufficient to make navigation difficult.

DEEP DRAFT VESSEL AND BARGE TRAFFIC

The maximum projection of vessel mix and in/out movements for the year 2030, for vessels drafting more than 15 feet and assuming the channels are deepened, are summarized below:

Table 2
NUMBER OF VESSEL TRIPS TO PORT OF RICHMOND
YEAR 2030

<u>Type of Vessel</u>	<u>Range of Vessel Draft</u>	<u>Maximum Number of In/Out Movements</u>
Container Cargo	34-36 feet	488
Liquid Bulk Cargo	31-36 feet	184
Dry Bulk Cargo	30-36 feet	68
General Cargo	≤ 30 feet	84
Other Liquid Bulk Cargo	> 15 feet	172
		<u>996</u>

At present there are no containership berthing facilities in Richmond Harbor. Two berths are planned for construction by 1980, four additional berths by 1990, and three additional berths by 2000, for a total of nine container berths. Generally, the remainder of the deep-draft vessel traffic consists of bulk cargo. The maximum number of projected in/out movements by the year 2030 is 996, i.e. 498 deep-draft vessels per year will call at Richmond, or less than 2 per day.

Barge traffic consists of barges with beams less than 50 feet. The barge traffic is estimated at 142 in/out movements per year or 76 round trip movements per year. Bray Oil Company had 56 barges in 1975. The barge traffic, therefore, is considered to be minor.

Deep draft and barge traffic does not follow any particular frequency, i.e. there is no peak time of shipping either seasonally, daily or hourly. Therefore, for the purposes of this study, the traffic is considered to be uniformly distributed with no more than, say, four vessel calls in any one day.

SMALL CRAFT TRAFFIC

Introduction

Small craft recreation has grown in the last twenty years at an unprecedented rate. Because of a lack of data, some of the marina entrance channels were underdesigned. Generally, selection of entrance widths have been left up to judgment rather than on specific criteria, because hard data in the literature has been sadly lacking. Fortunately, some data is now available, and coupled with experience, sound conclusions can be drawn for Richmond.

Methodology

The methodology employed in this study is to first estimate the ultimate boat traffic volumes in Point Potrero Reach and Point Potrero Turn for deep-draft vessels, barges and small craft. Once these traffic counts are determined, there are a couple of analytical approaches to determining the proper entrance channel width, or hence, whether the existing channel, Point Potrero Reach, is suitable or whether it needs to be widened or a new channel dredged. Also, some comparisons will be made with other small craft marinas and with a combination small craft and deep-draft port, i.e. the Oakland/Alameda Estuary.

Boat traffic was determined in the previous section for deep-draft vessels. In this section, small boat traffic will be determined.

Boat counts have been made at Alamitos Bay (Long Beach), Newport Bay (Orange County), and Huntington Harbour (Orange County). The consultant was not able to identify a Bay area marina which had taken any traffic counts. Usually an agency will not take counts unless they are experiencing some congestion problem. In this section, the results of a rigorous analysis of these three marinas will be presented. The approach taken is to determine the boat generation rates from these marinas, and then decide on an appropriate generation rate for the small craft berths in the proposed Richmond Marina, Santa Fe Channel, and Brickyard Cove. The average daily generation rate is defined as the percentage of boats that will leave their slips on a given day, which when multiplied times the total number of slips will give the average daily traffic. From this same data, the peak hour factor which is the ratio of peak hour

traffic to average daily traffic is determined, and then an appropriate peak hour factor is selected for use at Richmond. The launch ramp traffic is estimated, and the total boat traffic in Point Potrero Turn and Point Potrero Reach can be determined.

The basic approach is to determine the peak hour boat traffic on a typical summer Sunday, and then size a channel for this volume which will fall short of a congestion problem, or before potential collisions will occur. As the data will demonstrate, a typical summer Sunday will have between 10 and 40 percent more traffic than a Saturday and four to five times as much as a weekday. The traffic in winter can be expected to be much less than in summer. The only days which might exceed a summer Sunday would be one of the big three holiday weekends - Memorial Day, Fourth of July and Labor Day.

Traffic Data From Other Marinas

Alamitos Bay. The City of Long Beach conducted an extensive survey program during the summer of 1974. Boat traffic counts were taken from 6:00 a.m. to 6:00 p.m. on the following days: July 4, 5, 6, 7 (Thursday - Sunday); August 17 - 18 (Saturday - Sunday); August 24 - 25 (Saturday - Sunday); August 28 (Wednesday); and Labor Day Weekend, August 30 - September 2 (Friday - Monday). The counts were taken at six stations around the Bay along with interviews at the launch ramps and beach launching areas. The observers were part-time summer personnel, and in some cases there were gaps in the data. For the purposes of this study, assumptions were made where data was missing. The launch ramp data seemed reasonably accurate as far as launchings were concerned, but woefully deficient as to landings. However, the interviews at the launch ramps divulged which boats were ocean-going and which boats were going to stay within the Bay.

For this study, Labor Day weekend was selected for analysis. The traffic counts for the entrance channel were tabulated by the hour. By subtracting the boats that were launched from the total traffic count, the traffic count for boats that originated from slips was determined. This net traffic count for daily traffic was divided by the total number of slips to determine the average daily generation rate for boats leaving the harbor. The peak hour factor was determined on total traffic. Since the data did not accurately separate sailboats and power boats, all types of boats were lumped together.

At this point, it is important to explain that many boats will leave a harbor in Southern California for a weekend trip or sometimes a week-long trip with such destinations as Catalina Island, the Channel Islands, Santa Barbara and San Diego. For the four-day Labor Day weekend at Alamitos Bay, 3,155 boats were counted as outbound and 3,107 boats were counted as inbound. On Friday, there were 341 out vs. 239 in; Saturday 945 out vs. 807 in; Sunday 1001 out vs. 881 in; and on Monday 868 out vs. 1180 in.

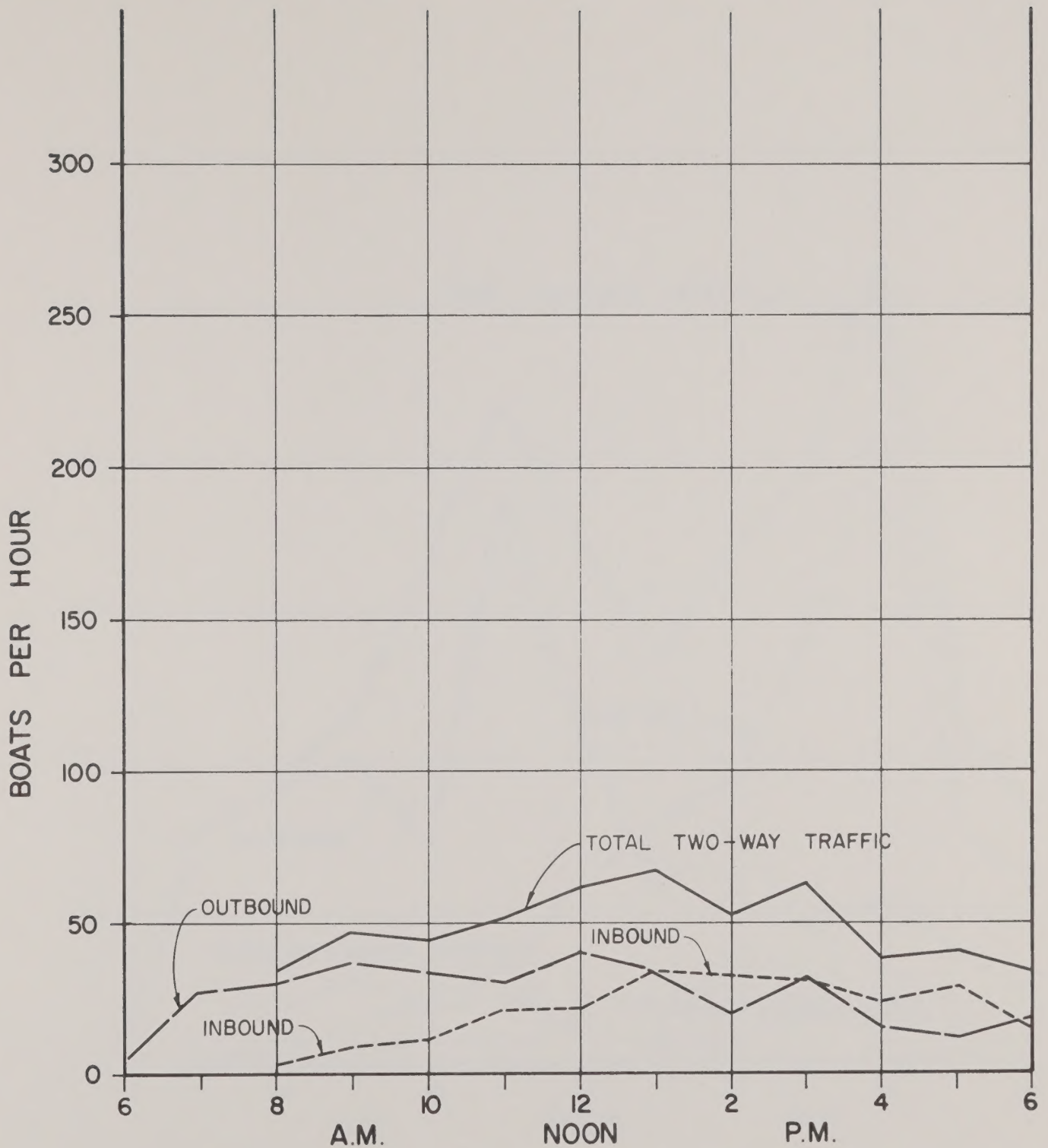
The average daily generation rates and peak hour factors for Labor Day weekend are developed in Table 3 below.

Table 3
AVERAGE DAILY GENERATION RATES AND PEAK HOUR FACTORS
LABOR DAY WEEKEND, 1974, ALAMITOS BAY

	<u>FRI</u> <u>8/30</u>	<u>SAT</u> <u>8/31</u>	<u>SUN</u> <u>9/1</u>	<u>MON</u> <u>9/2</u>
Total No. of Slips = 3185				
Total Daily Outbound	341	945	1001	868
Daily Launch Traffic Outbound	61	195	216	282
Net Wet Storage Outbound	280	750	785	586
Average Daily Generation Rate	8.8%	23.5%	24.6%	18.4%
Total Daily Inbound	239	807	881	1180
Total Daily Two-Way Traffic	580	1752	1882	2048
Total Peak Hour Outbound	40	186	194	115
Peak Hour Factor (Pk. Hr./Total Daily)	11.7%	19.7%	19.4%	13.2%
Total Peak Hour Inbound	34	210	185	194
Peak Hour Factor (Pk. Hr./Total Daily)	14.2%	26.0%	21.0%	16.4%
Total Peak Hour, Two-Way Traffic	67	263	288	280
Peak Hour Factor (Pk.Hr./Total Daily Average One Way)	23.1%	30.0%	30.6%	27.3%

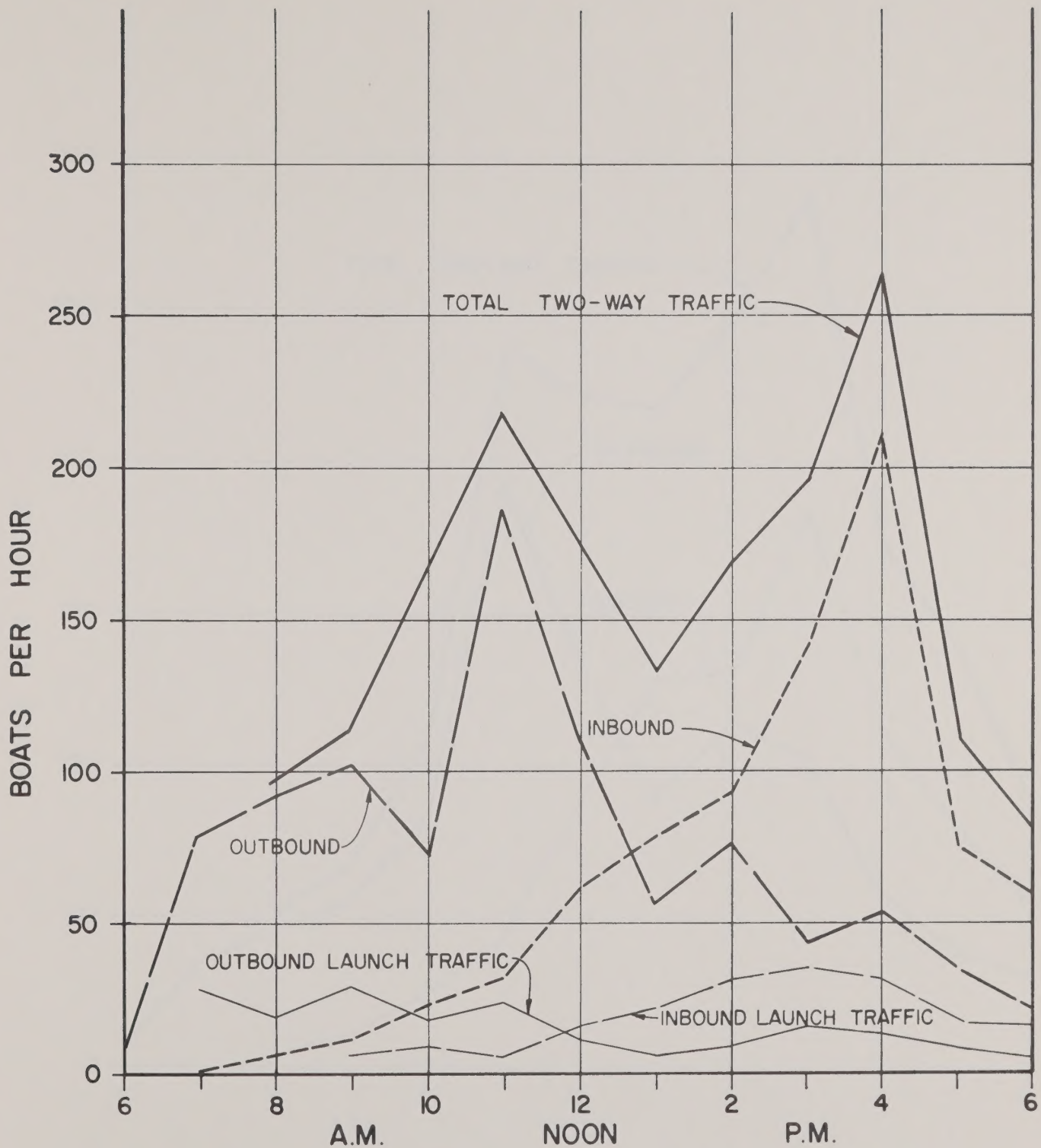
The traffic data has been graphically displayed on Plates 3, 4, 5 and 6, following, to show the hourly and daily variations in traffic.

Newport Bay. The Orange County Harbor District has made detailed boat counts in the entrance channel from 1963 to 1971. The counts were made on a typical summer weekend and a Wednesday, for both daily and peak hour traffic. Unfortunately, launch ramp traffic data was not taken, therefore it is impossible to isolate the traffic originating from the slips. If we assume that all of the sailboats come from slips, some reasonable generation rates can be derived for sailboats. Average daily generation rates for sailboats and peak hour factors for outboards, power boats and sailboats for the years 1967, 1969, 1970 and 1971 are shown in Table 4 following Plate 6:



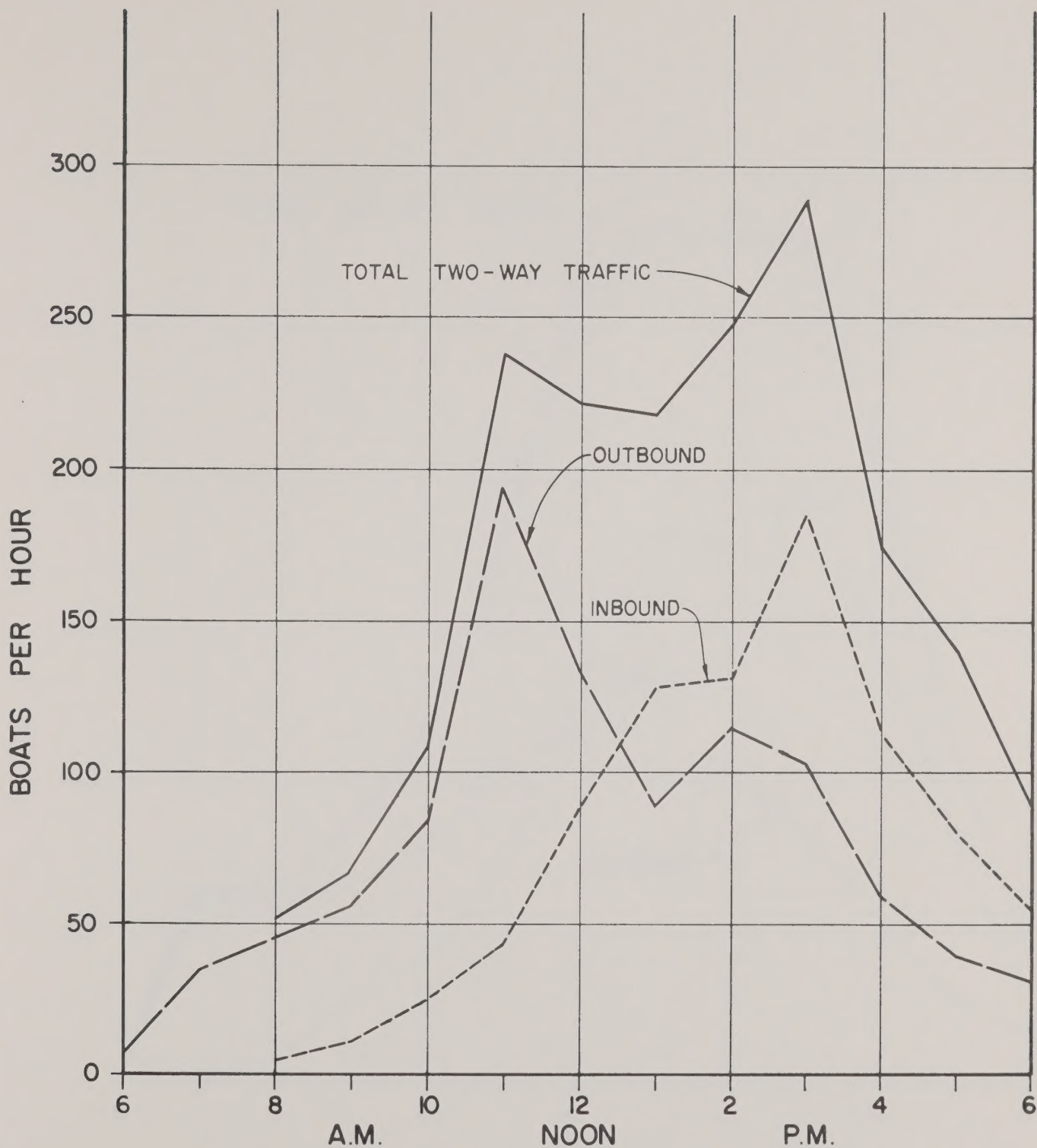
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

ALAMITOS BAY, LONG BEACH, CALIFORNIA
BOAT TRAFFIC - ENTRANCE CHANNEL
FRIDAY AUG. 30, 1974



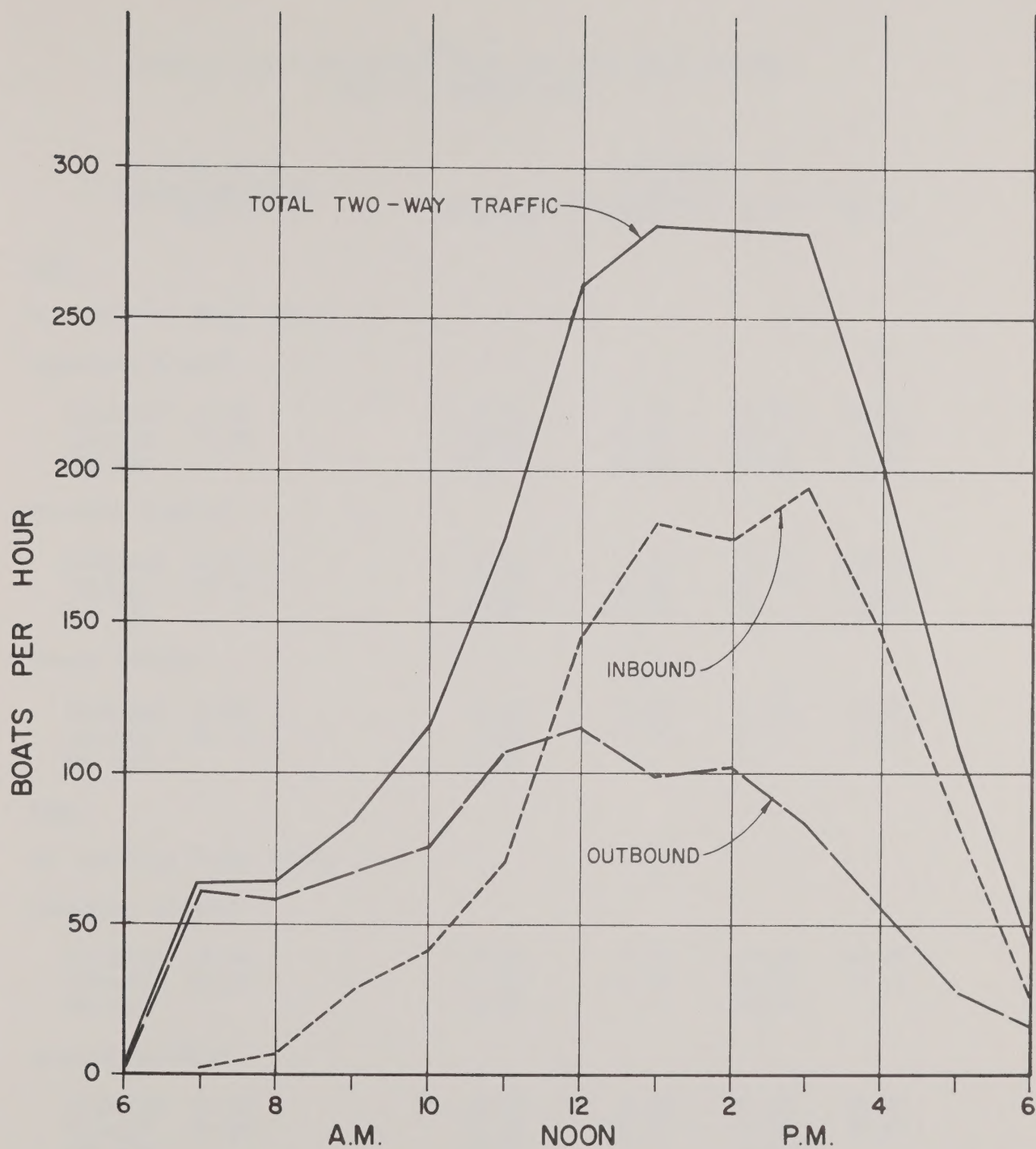
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

ALAMITOS BAY, LONG BEACH, CALIFORNIA
BOAT TRAFFIC - ENTRANCE CHANNEL
SATURDAY AUG. 31, 1974



KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

ALAMITOS BAY, LONG BEACH, CALIFORNIA
BOAT TRAFFIC - ENTRANCE CHANNEL
SUNDAY SEPT. 1, 1974



KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

ALAMITOS BAY, LONG BEACH, CALIFORNIA
BOAT TRAFFIC - ENTRANCE CHANNEL
MONDAY SEPT. 2, 1976 (LABOR DAY)

Table 4
AVERAGE DAILY GENERATION RATES AND PEAK HOUR FACTORS
1967-71, NEWPORT BAY

Average Daily Generation Rates		Peak Hour (%)			
Sail %		Outboard	Power	Sail	Total
<u>1967</u>					
No. Sailboat Slips (3129)					
Wednesday 8/23/67					
Outbound	6.9%	8.2%	5.4%	18.4%	10.1%
Inbound	7.2%	15.6%	11.4%	18.5%	14.8%
Two Way		24.0%	16.8%	36.8%	24.9%
Saturday 8/19/67					
Outbound	19.6%	8.0%	7.7%	14.7%	10.3%
Inbound	17.8%	9.6%	10.8%	17.5%	12.7%
Two Way		14.5%	16.4%	30.1%	20.7%
Sunday 8/20/67					
Outbound	14.9%	9.1%	13.2%	9.9%	11.0%
Inbound	19.7%	9.0%	12.3%	18.6%	13.8%
Two Way		17.5%	-	-	-
<u>1969</u>					
No. Sailboat Slips (3588)					
Wednesday 8/20/69					
Outbound	18.0%	9.5%	5.7%	21.6%	15.0%
Inbound	20.0%	17.7%	27.8%	29.5%	27.1%
Two Way		26.0%	-	45.0%	-
Saturday 8/23/69					
Outbound	12.8%	8.4%	9.8%	16.5%	11.7%
Inbound	10.9%	12.1%	25.2%	15.9%	19.5%
Two Way		15.2%	-	24.0%	-
Sunday 8/24/69					
Outbound	11.5%	15.3%	9.6%	16.4%	13.5%
Inbound	13.5%	15.2%	19.3%	14.6%	15.7%
Two Way		23.6%	-	-	-

Table 4 (Continued)

Average Daily Generation Rates		Peak Hour (%)			
Sail %		Outboard	Power	Sail	Total
<u>1970</u>					
No. Sailboat Slips (3800)					
Wednesday 8/19/70					
Outbound	4.8%	9.0%	6.7%	22.0%	11.9%
Inbound	5.4%	10.9%	14.8%	14.0%	13.5%
Two Way		18.8%	-	-	-
Saturday 8/22/70					
Outbound	13.3%	11.4%	8.0%	18.0%	12.2%
Inbound	15.1%	11.9%	17.2%	20.1%	17.0%
Two Way		17.8%	23.4%	31.0%	24.6%
Sunday 8/23/70					
Outbound	15.6%	10.2%	11.0%	22.8%	14.8%
Inbound	16.8%	13.9%	14.3%	22.4%	16.9%
Two Way		22.0%	24.6%	35.0%	27.6%
<u>1971</u>					
No. Sailboat Slips (4000)					
Wednesday 8/18/71					
Outbound	6.8%	5.0%	6.7%	18.5%	11.2%
Inbound	6.6%	16.2%	13.0%	16.8%	15.3%
Two Way		-	17.6%	24.8%	-
Saturday 8/21/71					
Outbound	15.8%	11.2%	5.2%	18.2%	11.6%
Inbound	17.3%	8.6%	14.7%	23.1%	16.6%
Two Way		-	-	31.6%	-
Sunday 8/22/71					
Outbound	17.4%	14.8%	11.9%	15.7%	14.3%
Inbound	19.2%	18.3%	14.3%	21.5%	18.2%
Two Way		33.6%	26.6%	37.6%	32.8%

In a report for Channel Islands Harbor,^{1/} average daily generation rates and peak hour factors for Newport Bay are summarized for the years 1963-69, as shown below in Table 5.

Table 5
AVERAGE DAILY GENERATION RATES AND PEAK HOUR FACTORS
1963-69, NEWPORT BAY

	<u>Average Daily Generation Rates/Total Fleet</u>		
	<u>Sunday</u>	<u>Saturday</u>	<u>Weekday</u>
1963	.31	.26	.15
1964	.37	.29	.14
1965	.36	.31	.11
1966	.34	.21	.14
1967	.28	.28	.12
1968	.23	.34	.17
1969	.24	.23	.22
Average	.32	.27	.15

	<u>Average Daily Generation Rates/Sail & Power Fleet</u>			
	<u>Sunday</u>		<u>Saturday</u>	
	<u>Sail</u>	<u>Power</u>	<u>Sail</u>	<u>Power</u>
1963	.64	.16	.49	.16
1964	.67	.24	.54	.17
1965	.62	.23	.52	.18
1966	.50	.27	.35	.14
1967	.41	.20	.39	.22
1968	.48	.28	.38	.14
1969	.31	.17	.35	.16
Average	.52	.22	.43	.17

^{1/}"A study of the Effects of Waterway Expansion, Channel Islands Harbor", Moffatt and Nichol, Engineers, April, 1970.

Table 5 (Continued)

Average Peak Hour Factors, 1963-69 - Summer Sunday

	<u>Outbound</u>	<u>Inbound</u>
Power	.10	.15
Outboard	.13	.15
Sail	.20	.20

Huntington Harbour. A boat traffic study was undertaken at Huntington Harbour in order to determine whether the harbor waterways are capable of supporting the traffic that will be generated from a fully developed harbor. The study was conducted on nine days during the summer of 1975. The days chosen were June 21, 22, 27, 28 and 29, and July 2, 4, 5, and 6. Traffic was measured from 6:00 a.m. until 8:00 p.m.

Huntington Harbour contains a mixture of slips for single family houses and condominiums, and leased slips for the general public. The study showed that the leased slips tend to have the lowest generation rates. Since Richmond Marina will have all leased slips, even though the land use is predominantly residential, the results for leased slips for Huntington Harbour are deemed more appropriate for application to Richmond.

Observers were posted at various clusters of slips during the study. They counted each time a boat left its slip and each time a boat returned to its slip. This is a very direct method of determining a slip generation rate. The hourly traffic data that was taken in this survey is not valuable to this study. The results of the survey are shown below in Table 6.

Table 6
AVERAGE DAILY GENERATION RATES
HUNTINGTON HARBOUR, 1975

Average Weekday	5.3%
Average Saturday	12.5%
Average Sunday	16.1%
Average Holiday Weekend	20.4%

Small Craft Traffic at Richmond

After a thorough review of the survey data just presented, the consultant judged the following factors in Table 7 to be appropriate for use at Richmond. For Richmond it is not important to differentiate between power boats and sailboats, because sailboats will sail on a straight course in Point Potrero Reach most of the time.

Table 7
AVERAGE DAILY GENERATION RATES AND PEAK HOUR FACTORS
FOR USE IN PROJECTING BOAT TRAFFIC AT RICHMOND

	<u>Average Daily Generation Rate</u>		
Saturday			.18
Sunday			.20
Holiday Sunday			.24

	<u>Peak Hour Factors</u>		
	<u>Outbound</u>	<u>Inbound</u>	<u>Total Two Way</u>
Berthed Boats	.15	.20	.30
Launched Boats	.15	.20	.25

In order to estimate traffic it is necessary to determine the berthing population. There are two critical locations in the harbor channel that need to be analyzed: Point Potrero Turn where the boats from the Santa Fe Channel and the proposed Richmond Marina converge into a sharp turn; and Point Potrero Reach where the boats from Brickyard Cove join the traffic. The berthing population tributary to these two critical locations is tabulated in Table 8.

Table 8
SLIPS IN RICHMOND AREA

	<u>1976</u>	<u>1979</u>	<u>1983</u>	<u>1986</u>	<u>1989</u>
<u>Tributary to Point Potrero Turn</u>					
Richmond Marina (includes San Pablo Avenue Sportsmens Club)	210	718	1142	1541	1756
Decker's Richmond Yacht Harbor	60	60	60	60	60
Channel Marina	64	64	64	64	64
Point San Pablo Yacht Club	<u>42</u>	<u>92</u>	<u>92</u>	<u>92</u>	<u>92</u>
Total Slips Tributary to Point Potrero Turn	376	934	1358	1757	1972
<u>Tributary to Point Potrero Reach</u> (All of the above plus those below)					
Brickyard Cove (Richmond Yacht Club)	260	260	260	260	260
Brickyard Cove (Residential)	<u>135</u>	<u>300</u>	<u>500</u>	<u>500</u>	<u>500</u>
Total Slips Tributary to Point Potrero Reach	771	1494	2118	2517	2732

By applying the factors from Table 7 to the number of slips in Table 8, the boat traffic volumes can be predicted for berthed boats. Launching facilities in the study area consist of the following:

1. A one-lane launch ramp at the end of Santa Fe Channel which will be phased out when the new launch ramp is constructed in the Inner Harbor Basin.
2. A four-lane launch ramp is proposed for the Richmond Marina in the Inner Harbor Basin.
3. A marine railway at the San Pablo Avenue Sportsmen's Club in the Inner Harbor Basin.
4. Two hoists at the Richmond Yacht Club in Brickyard Cove.

The traffic from the launch ramps are considered to be operating at 35 launchings/landings per lane per day, which is a capacity figure and represents a summer Sunday or holiday. The remainder will come from the marine railway and hoists. The Richmond boat traffic is presented in Table 9.

Table 9
SMALL CRAFT TRAFFIC AT POINT POTRERO TURN AND
POINT POTRERO REACH ON TYPICAL SUMMER SUNDAY

	<u>Point Potrero Turn</u>			<u>Point Potrero Reach</u>		
	<u>Total</u>	<u>Berthed Boats</u>	<u>Launched Boats</u>	<u>Total</u>	<u>Berthed Boats</u>	<u>Launched Boats</u>
<u>1976</u>						
Berthed boats	376	376	-	771	771	-
One-way daily traffic	110	75	35	194	154	40
Peak-hour two-way traffic	32	23	9	56	46	10
<u>1979</u>						
Berthed boats	934	934	-	1494	1494	-
One-way daily traffic	327	187	140	454	299	155
Peak-hour two-way traffic	91	56	35	129	90	39

Table 9 (Continued)

	<u>Total</u>	<u>Berthed Boats</u>	<u>Launched Boats</u>	<u>Total</u>	<u>Berthed Boats</u>	<u>Launched Boats</u>
<u>1983</u>						
Berthed boats	1358	1358	-	2118	2118	-
One-way daily traffic	412	272	140	579	424	155
Peak-hour two-way traffic	117	82	35	166	127	39
<u>1986</u>						
Berthed boats	1757	1757	-	2517	2517	-
One-way daily traffic	491	351	140	658	503	155
Peak-hour two-way traffic	140	105	35	190	151	39
<u>1989</u>						
Berthed boats	1972	1972	-	2732	2732	-
One-way daily traffic	534	394	140	701	546	155
Peak-hour two-way traffic	153	118	35	203	164	39

From the data presented earlier from the Southern California marinas, an hourly model was developed for boat traffic. From this model and the traffic shown in Table 9, hourly distributions of small craft boat traffic were developed for Richmond traffic in Point Potrero Turn and Point Potrero Reach. These are shown on Plates 7 through 16.

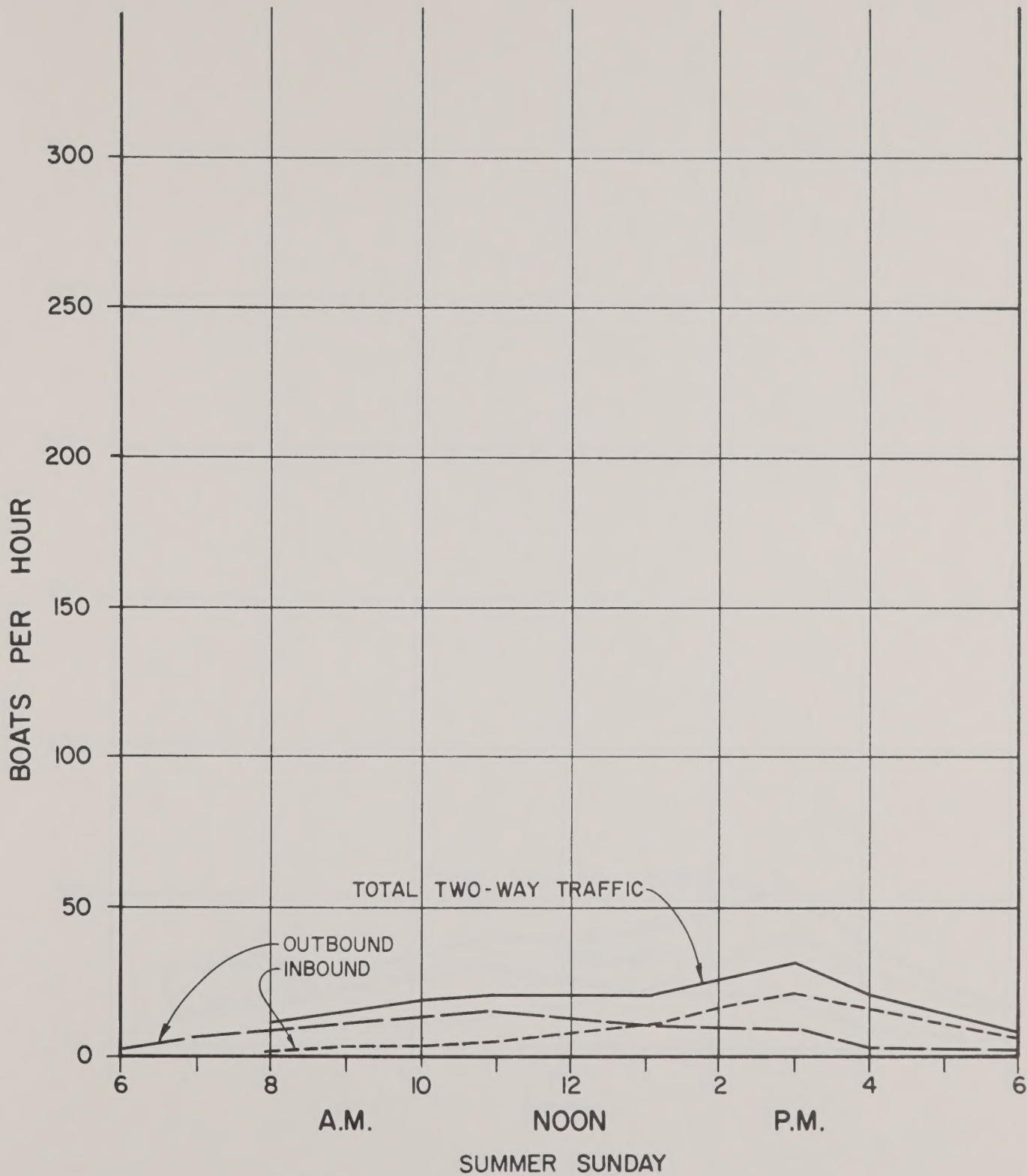
ADEQUACY OF CHANNELS

Introduction

The next step is to assess the adequacy of Point Potrero Turn and Point Potrero Reach to handle the mix of small craft and deep-draft traffic. Two analytical methods are used in this section to compute the width of channel required. In addition, through the use of case studies, data on other marinas and ports will be presented to test the analytical results.

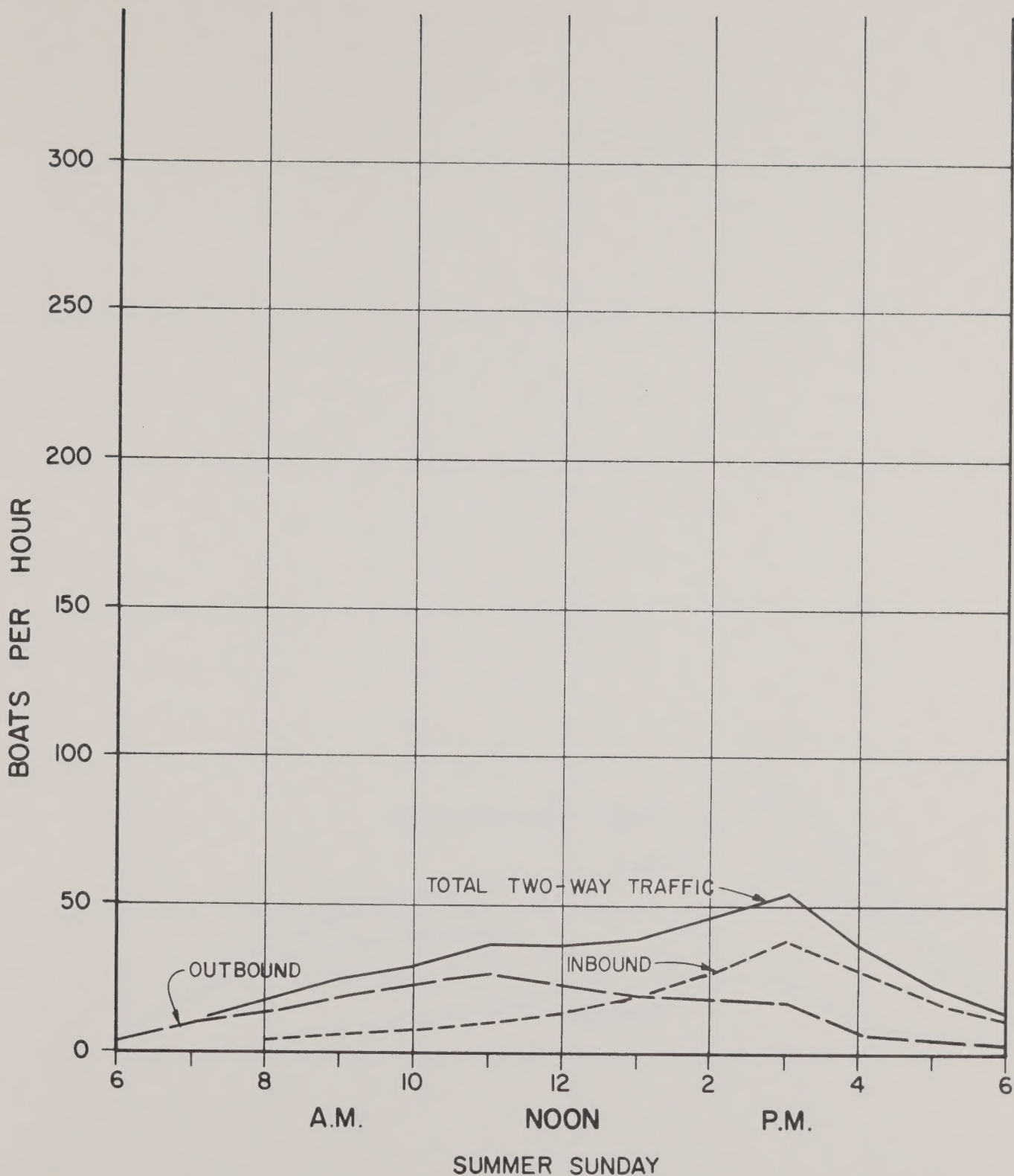
Analytical Determination of Channel Adequacy

There are two basic approaches to this problem. The first method is very straight-forward and covers the case when sailboats can travel in a straight course, which is predicated on the favorable wind conditions. The wind is favorable more than 75 percent of the time as previously discussed.



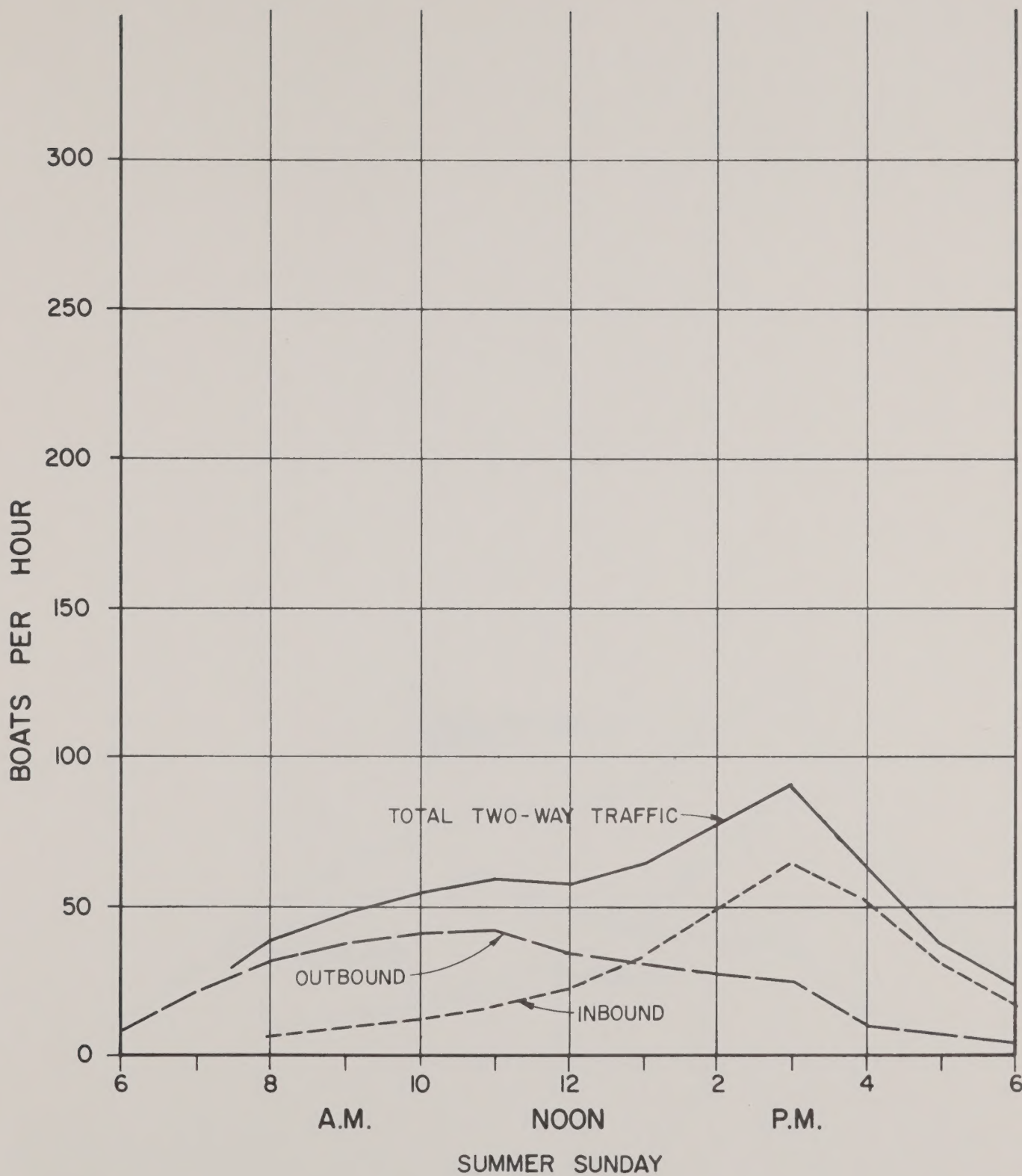
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
AT POINT POTRERO TURN-1976
RICHMOND, CALIFORNIA



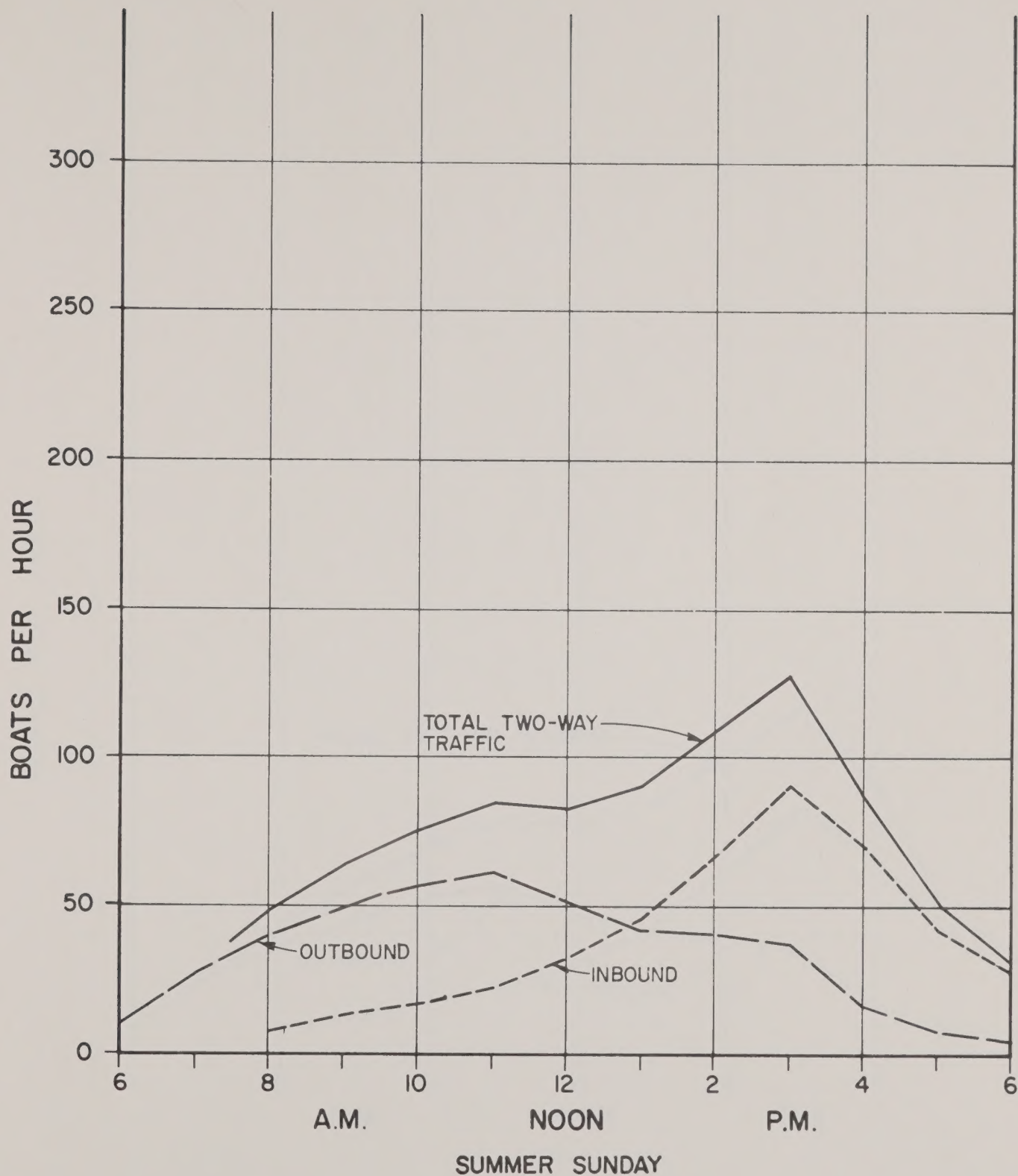
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
IN POINT POTRERO REACH-1976
RICHMOND, CALIFORNIA



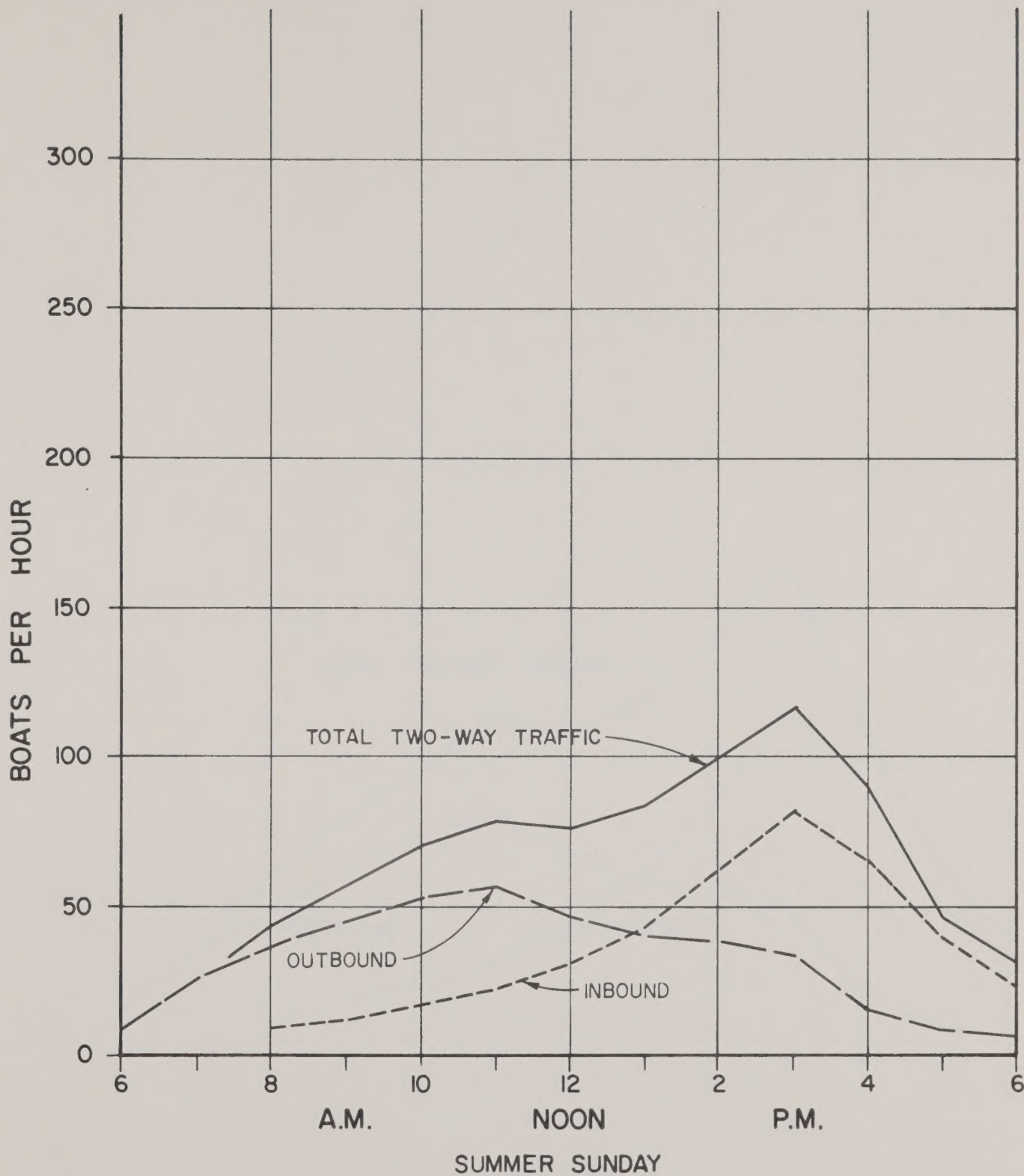
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
AT POINT POTRERO TURN-1979
RICHMOND, CALIFORNIA



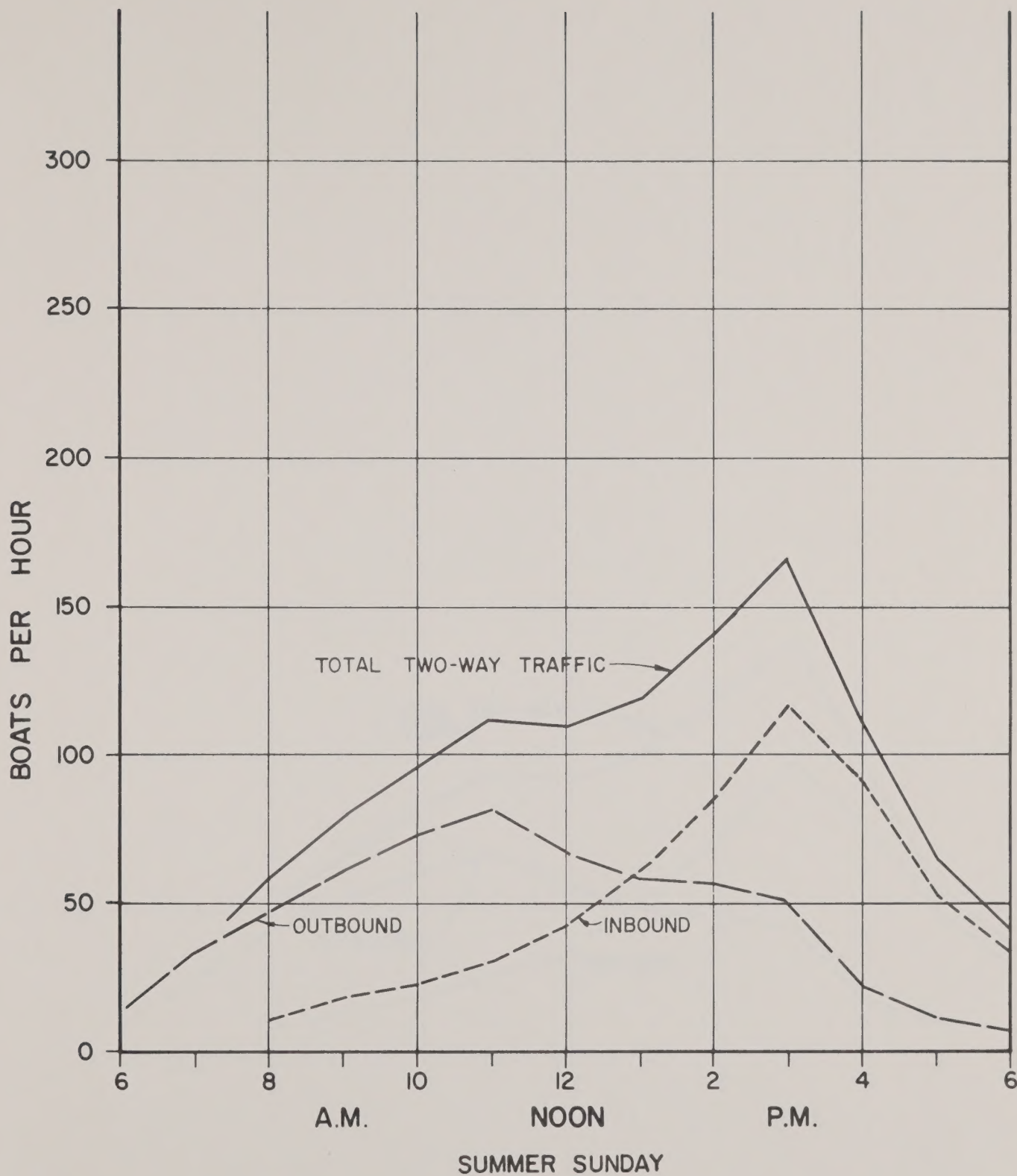
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
IN POINT POTRERO REACH-1979
RICHMOND, CALIFORNIA



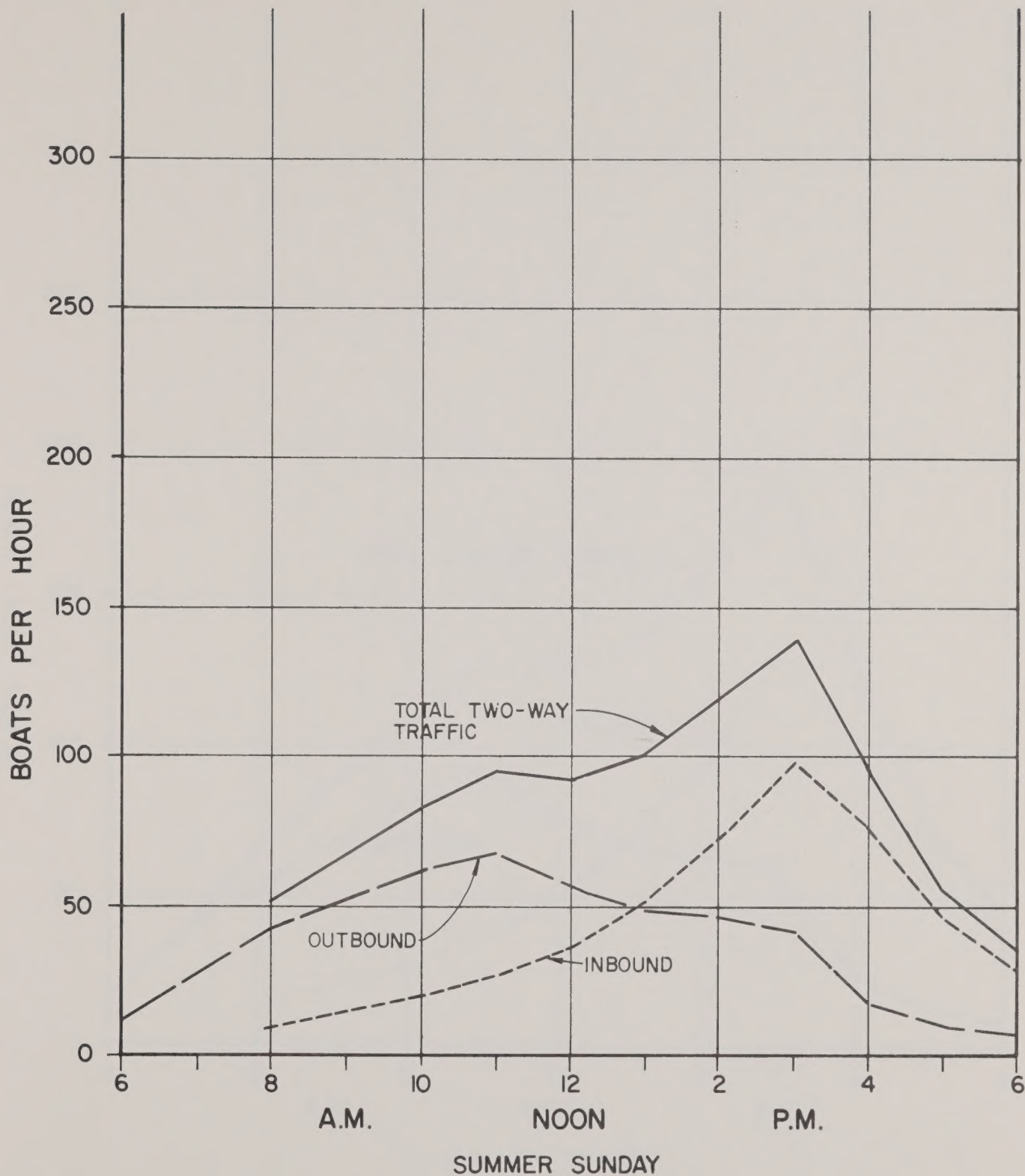
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
AT POINT POTRERO TURN-1983
RICHMOND, CALIFORNIA



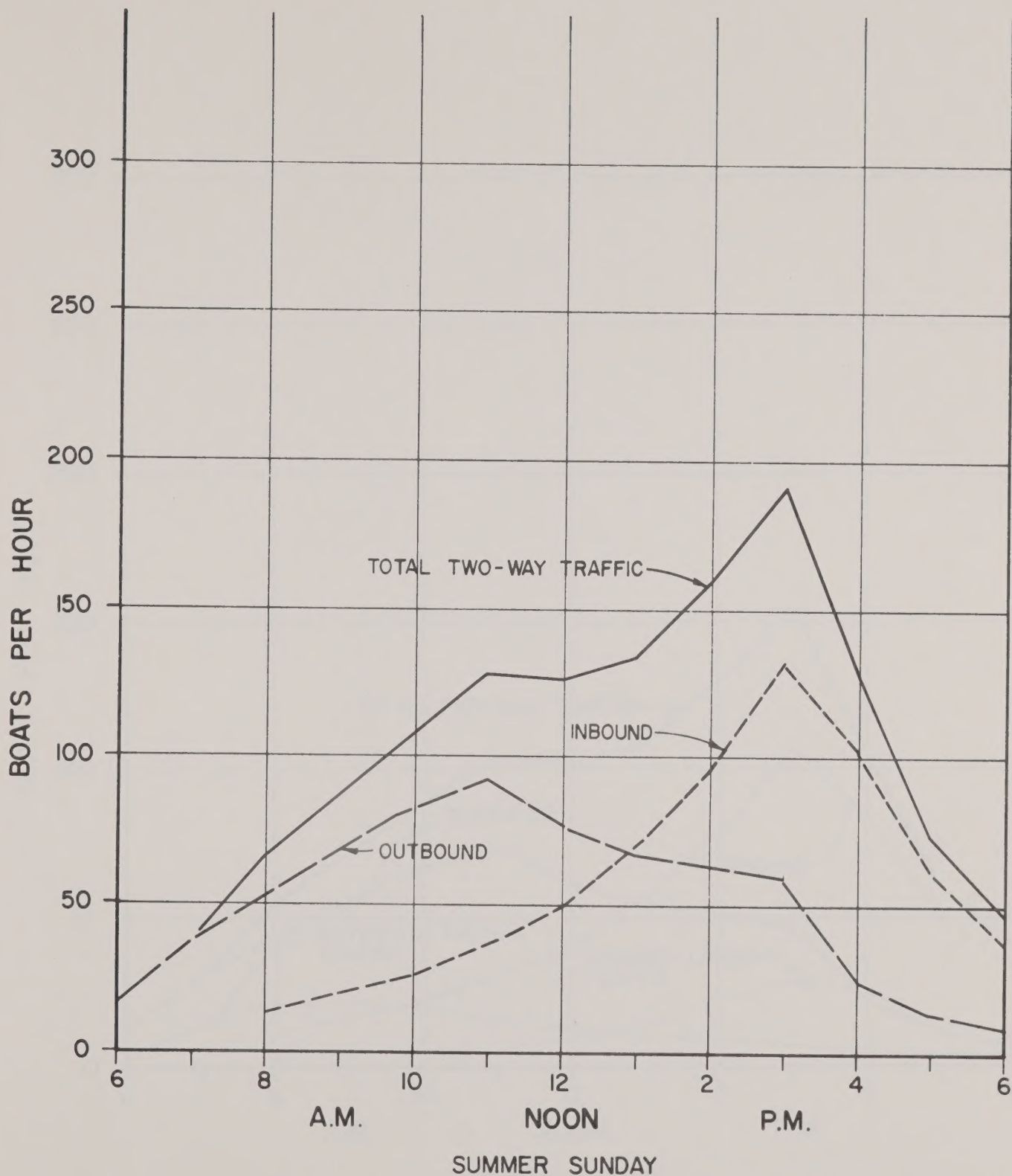
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
IN POINT POTRERO REACH-1983
RICHMOND, CALIFORNIA



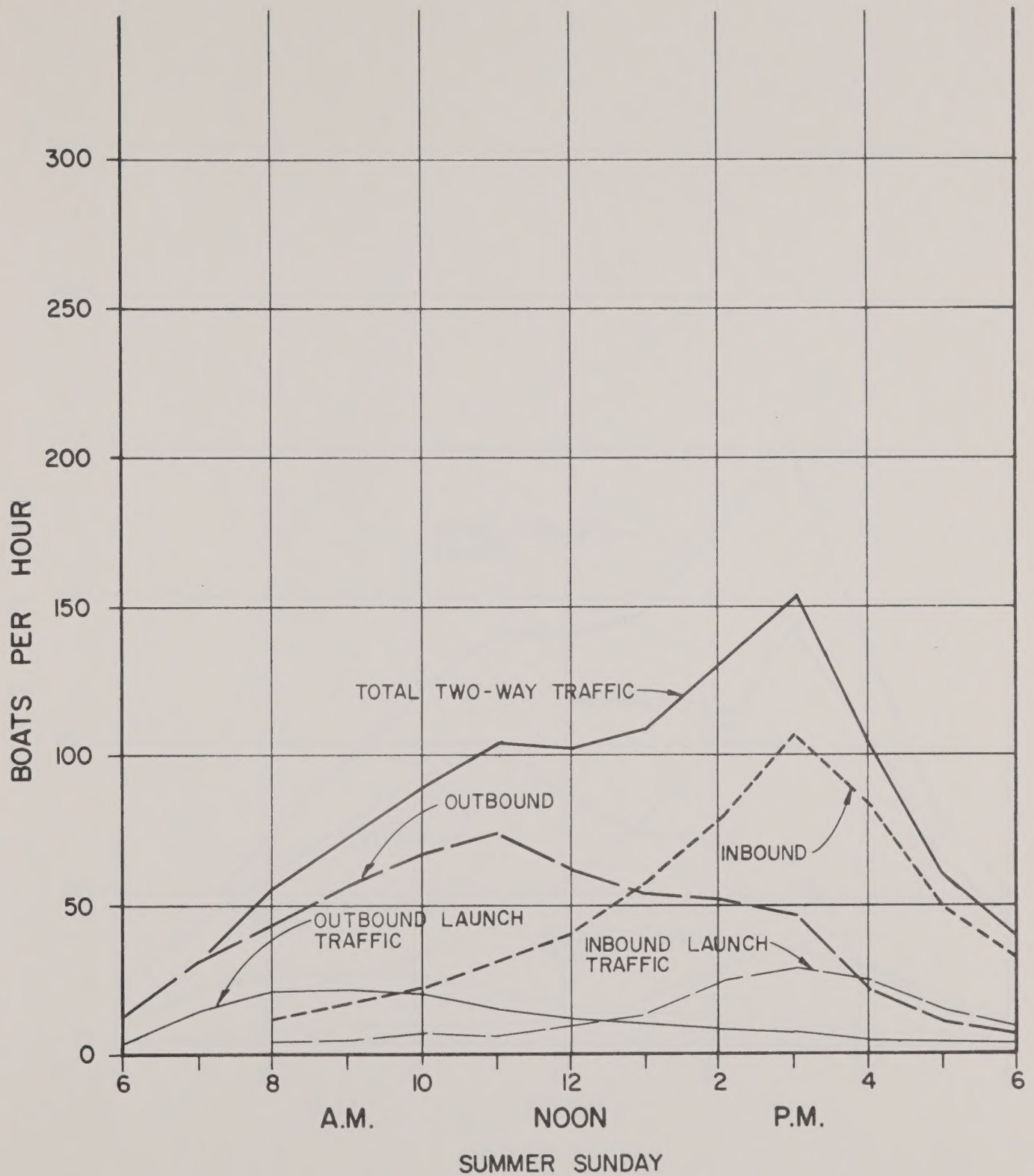
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
AT POINT POTRERO TURN-1986
RICHMOND, CALIFORNIA



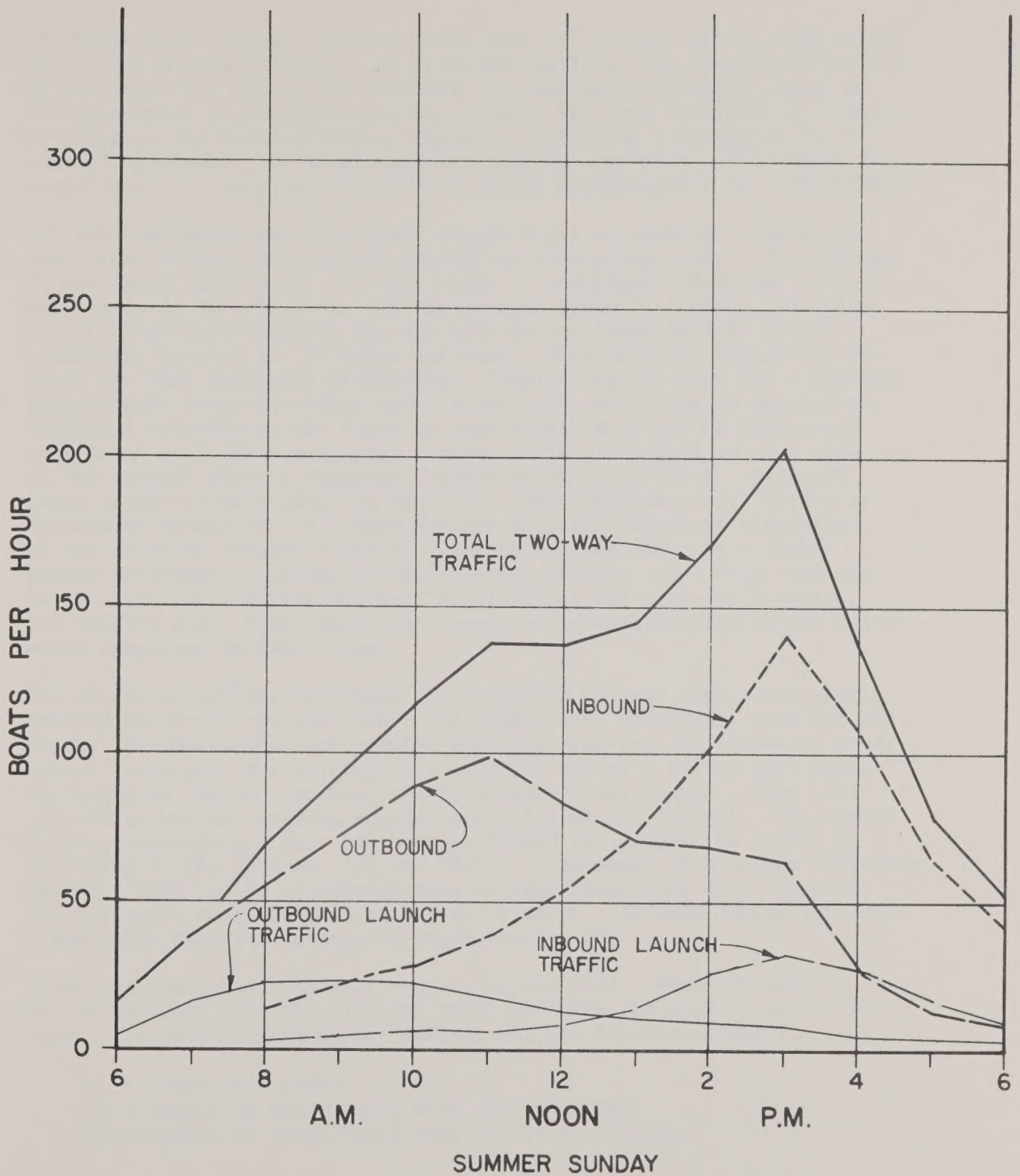
KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
IN POINT POTRERO REACH-1986
RICHMOND, CALIFORNIA



KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
AT POINT POTRERO TURN-1989
RICHMOND, CALIFORNIA



KOEBIG, INC.
ENGINEERING-ARCHITECTURE-PLANNING
LOS ANGELES, CALIFORNIA

PROJECTED SMALL CRAFT TRAFFIC
IN POINT POTRERO REACH-1989
RICHMOND, CALIFORNIA

The deep-draft vessels represent less than 0.3 percent of the 1989 daily traffic on a summer Sunday. As discussed earlier, the deep-draft traffic is less than two in-and-out movements per day on an average. Based on the experience of San Francisco Bay pilots, the time required for vessels to navigate the Richmond Harbor Channels, including Southampton Shoal connecting channel, is 30 minutes for each one way trip. This means the large vessel is only in Point Potrero Reach approximately 15 - 20 minutes.

For the time being the deep-draft vessel shall be ignored. The first analytical method utilizes the concept of blockading areas. The average 35 foot boat, with a 11 - 12 foot beam, is considered to occupy a blockading area of 30 x 90 feet. If the average speed is 4 knots, the theoretical peak-hour capacity for one lane is the speed divided by the blockading length, or 270 boats per hour. This capacity figure far exceeds the 1989 peak-hour prediction. Considering the need for a passing lane in each direction since small craft boats will tend to operate at different velocities, two lanes in each direction shall be sufficient. Four lanes at 30 feet each plus a clear width of 25 feet on each side of the channel gives a required channel width of 170 feet. Although lanes cannot be delineated on the water, boat operators will naturally distribute themselves in a lane pattern to avoid dangerous situations. If the required channel width of 170 feet for peak-hour on a summer Sunday afternoon is placed in the existing 500-foot wide Point Potrero Reach, that still leaves 330 feet of width for the deep-draft vessel. The smaller boats with their high degree of maneuverability should easily avoid dangerous confrontations.

The second method^{1/} was developed for analyzing channel conditions where tacking sailboats are involved. The theory uses blockading area for the boats. Sailboats that are running with the wind are considered as power boats, since they are sailing on a straight course. As the sail boats tacking into the wind go back and forth across the channel, they will interfere with the vessels moving parallel with the channel. The number of interferences per acre per hour is termed the Congestion Index, C. According to the authors, Ely and Nichol, interviews with harbor officials have led them to the conclusion that a Congestion Index of 10 is about the threshold where congestion begins to occur. Serious congestion problems occur when the Congestion Index reaches 15.

There are two situations that need to be reviewed: When the wind is out of the east parallel with the Reach and when the wind is out of the west. The following terms are defined for the Ely-Nichol model.

C = Congestion Index

Qi = Number of power boats with the wind/hour.

Qo = Number of power boats against the wind/hour.

^{1/} Ely, Allen L., and Nichol, John M., "Congestion in Marina Entrance Channels Due to Sailboats," Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE, Vol. 99, No. WW4, November, 1973.

V_p = Average velocity of power boats.
 θ = Angle between prevailing wind direction and channel.
 $Q = Q_o + Q_i$
 Q_s = Number of tacking sailboats per hour.
 L_p = Length of power boat blockading area.
 W = Width of channel.
 K = Constant depending on number of boats traveling in each direction and the angle θ .

$$\text{Ely-Nichol Model: } C = \frac{KQQ_sL_p}{W^2V_p} \text{ or } W = \left(\frac{KQQ_sL_p}{CV_p} \right)^{\frac{1}{2}}$$

For purposes of these analyses, assume that sailboats comprise 62 percent of the total fleet.

Condition No. 1: Easterly wind at 3:00 p.m., 1989. The wind blows out of the east in the summer months less than one percent of the time.

$$\begin{aligned}
 C &= 10 \\
 Q_s &= .62 (546) (.20) = 68 \\
 Q_i &= 63 \\
 Q_o &= 140 - 68 = 72 \\
 V_p &= 4 \text{ knots} \\
 \theta &= 0^\circ \\
 L_p &= 90 \text{ feet}
 \end{aligned}$$

$$\frac{Q_o}{Q_o + Q_i} = \frac{72}{135} = .53, \theta = 0^\circ, \text{ therefore } K = 16.5$$

$$W = \left(\frac{KQQ_sL_p}{CV_p} \right)^{\frac{1}{2}} = \left(\frac{16.5 \times 135 \times 68 \times 90}{10 \times 4} \right)^{\frac{1}{2}} = \underline{584 \text{ feet}}$$

Determine channel width for $C = 15$.

$$W = \left(\frac{16.5 \times 135 \times 68 \times 90}{15 \times 4} \right)^{\frac{1}{2}} = \underline{477 \text{ feet}}$$

Consider a wind out of the southeast, which blows in the summer months approximately 12 percent of the time.

$$\theta = 36^\circ, K = 8.38, C = 10$$

$$W = \left(\frac{8.38 \times 135 \times 68 \times 90}{10 \times 4} \right)^{\frac{1}{2}} = \underline{416 \text{ feet}}$$

Condition No. 2: Westerly wind at 11:00 a.m., 1989. This wind occurs in the summer months approximately nine percent of the time.

$$\begin{aligned}
 C &= 10 \\
 Q_s &= .62 (546) (.15) = 51 \\
 Q_i &= 39
 \end{aligned}$$

$$\begin{array}{ll}
 Q_o = 99-51 & = 48 \\
 V_p & = 4 \text{ knots} \\
 \theta & = 0^\circ \\
 L_p & = 90 \text{ feet}
 \end{array}$$

$$\frac{Q_o}{Q_o+Q_i} = \frac{48}{87} = .55, \theta = 0^\circ, \text{ therefore } K = 16.4$$

$$W = \frac{(16.4 \times 87 \times 51 \times 90)^{\frac{1}{2}}}{10 \times 4} = \underline{405 \text{ feet}}$$

Case Studies

Since the analytical approaches to this problem of boat traffic congestion are somewhat subjective, it is important to look at other harbors as case studies in order to verify the analytical solutions. The harbors under study include Southern California and Bay area harbors.

Newport Bay. There are approximately 9,200 slips in Newport Bay with at least another 1,000 boats in dry storage. The entrance channel width is 500 feet. The prevailing wind is perpendicular to the coast. The entrance channel is close to 45 degrees east of the prevailing wind thus permitting outgoing sailboats to sail on a straight course most of the time. The two-way peak-hour traffic on a summer Sunday is about 500 boats per hour vs. 203 for Richmond in 1989.

Huntington Harbour. Huntington Harbour has 1,756 boat slips and an eight-lane launch ramp. The access to the ocean is constricted under the Pacific Coast Highway Bridge which has a clear width of 110 feet and a clearance of 30 feet at mean low tide. Sailboats must lower their masts to clear the bridge and go under power. The average daily two-way traffic through the bridge for a typical summer Sunday is about 450 boats with a two-way peak-hour of 65 boats per hour. On Sunday, July 6, 1975, 102 boats at peak-hour passed under the bridge. After passing the bridge, boats must power through the U. S. Navy Anaheim Bay to reach the ocean. A second entrance to Huntington Harbour is in the conceptual planning stages to relieve the constriction caused by the bridge. The launch ramp accounts for about 37 percent of the traffic that is ocean-going.

Alamitos Bay. There are 3100 slips at Alamitos Bay with 2500 lineal feet of slip space (85 slips) available for transient craft. In addition, there are 40,000 launches per year on the ramps. The channel width is approximately 500 feet. The prevailing wind is perpendicular to the coast, as is the channel. Thus, outgoing sailboats must either tack or be under power to get out. The large number of tacking sailboats has caused excessive congestion. The channel has a new buoy system that divides the channel into inbound and outbound lanes, and according to the Harbor Patrol appears quite effective.

Marina del Rey is located north of Los Angeles International Airport and includes 6000 slips, 2000 boats in dry storage and a 10-lane launch ramp. The prevailing wind blows directly down the entrance channel. The entrance channel is 1000 feet wide (between the jetties). Tacking sailboats have caused a congestion problem in the past. There have been proposals to require sailboats to power out the channel, but this has met with a great deal of opposition from the sailors. Many sailboats don't have an outboard motor. The channel is now divided into three lanes - outbound, inbound, and sailing. Sailboats which desire to tack must use the sailing lane.

Coyote Point Marina consists of 475 slips. Its entrance channel is 100 feet wide for a distance of 800 feet. The depth of the channel is -8 MLLW and it terminates at -6 MLLW.

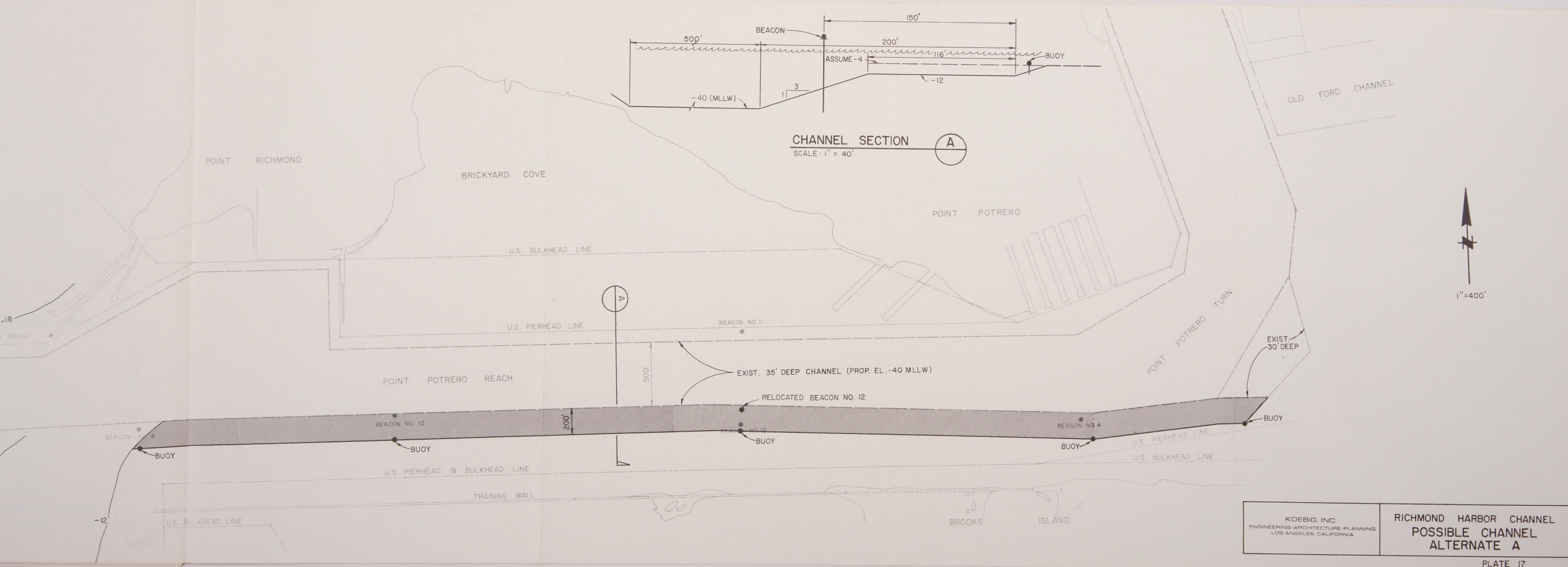
Oakland - Alameda Estuary. This case study is one of the more pertinent studies to the Richmond study. The Oakland/Alameda Estuary contains deep-draft berths and small craft marinas. There are 2,036 slips in the Estuary. Approximately 400 deep-draft vessel calls are made annually to the Estuary. The channel width is 500 to 600 feet. Interviews were held with representatives of the U. S. Coast Guard, Port of Oakland, and harbor masters of some of the marinas. There is no apparent conflict between deep-draft and small craft vessels. However, on a nice Sunday afternoon in the summer, there is some congestion between the small craft. There is a very high percentage of sailboats at these marinas, up to 80 percent in one case. Many of the boaters do not leave the Estuary, hence there might be 500 boats at one time sailing in the Estuary itself.

Alternate Channels for Richmond Harbor

In the next section, the recommendation for Richmond will be that no new channel capacity is needed at this time, and, in the consultant's judgment, will not be needed through the year 1989. Nevertheless, in the event that additional channel capacity is eventually either needed or considered desirable by local interests, it is considered prudent to discuss the alternatives. Two possible alternatives are presented.

Alternate A proposes a 200-foot wide channel from Point Potrero Turn to the end of the training wall. Alternate A is shown on Plate 17. The channel would be adjacent to the existing deep-draft channel. This channel would be adequate to accommodate all of the small craft traffic in a parallel-lane mode. Actually, there is enough room to add a 500 foot wide channel between the existing channel and the training wall, but it certainly is not necessary. About 300,000 cubic yards of dredging would be required to construct this 200-foot wide channel.

Alternate B proposes a 200-foot wide channel around the east side of Brooks Island as shown on Plate 18. The length of this channel is 3.9 miles. This channel would require over one million cubic yards of



dredging. With the channel in unprotected and shallow waters, the maintenance dredging would be most significant. The environmental impacts of dredging the Alternate B channel would appear to be more adverse than those associated with Alternate A. Clearly Alternate A is the preferred approach should additional channel capacity become necessary.

CONCLUSIONS AND RECOMMENDATIONS

This study has concerned itself with the adequacy of existing harbor channels imposed by the anticipated additional boat traffic in the Port of Richmond. The criteria utilized in the study are traffic congestion and traffic safety. Both mathematical models and case studies (prototype models) were utilized in this study. An absolute numerical solution is not reasonable for this study. In arriving at a conclusion, the consultant must be subjective and draw on the experience of many people. This study has been comprehensive and rigorous, and has exhausted all reasonable avenues.

From this study, the consultant has reached the following conclusions:

1. Small craft boating traffic follows somewhat predictable trends. Sailboats tend to leave the harbor in the early afternoon and return later in the afternoon. Inboard motor boats tend to leave at a more uniform rate throughout the day, although they return at about the same time as the sailboats. Outboard motor boats leave early "while the fishing is good" and return early in the afternoon before the wind becomes too troublesome.
2. A channel will accommodate approximately 4 to 6 times as many boats as a similar channel across which significant sailboat tacking occurs.
3. Weekend traffic is much heavier than weekday traffic. Sunday traffic is 10 - 40 percent heavier than Saturday traffic.
4. Small craft boats in Point Potrero Reach will have a peak-hour two-way traffic volume in 1989 on a typical summer Sunday of approximately 200 boats per hour. The existing channel can safely accommodate this volume, and additional channels do not appear necessary. If tacking becomes a problem during adverse wind conditions on peak days, this can be regulated.
5. Deep-draft vessel and barge traffic will average less than two trips per day each way. These vessels and small craft boats can co-habitate the same channel (Point Potrero Reach). The smaller boats have a high degree of maneuverability and

will easily avoid dangerous confrontations. Point Potrero Reach is 500 feet wide measured from the toe of slope at a depth of 35 feet. The side slope area of approximately 75 - 100 feet on each side of the channel can be used exclusively by small craft.

The consultant recommends that the City of Richmond, the Bay Conservation and Development Commission, and the Army Corps of Engineers permit the development of the Richmond Marina and hold in abeyance any plans for additional channel improvements relating to small craft needs. Channel deepening is required for the needs of the Port, however, and should be given serious study. The development of small craft traffic in Richmond will occur gradually over the next thirteen years. Should problems begin to develop, they will become apparent, and plans can be made early enough to solve them.

BIBLIOGRAPHY

"A Study of the Effects of Waterway Expansion, Channel Islands Harbor," Moffatt & Nichol, Engineers, Long Beach, California, April, 1970.

Ely, Allen L., and Nichol, John M., "Congestion in Marina Entrance Channels Due to Sailboats," Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE, Vol. 99, No. WW4, November, 1973.

"Huntington Harbour, Boat Traffic Capacity Study," Environmental Impact Profiles, Tustin, California, August, 1975.

Long Beach, City of, Boat Traffic Survey Data For Alamitos Bay, Summer, 1974.

Orange County Harbor District, Boat Traffic Survey Data for Newport Bay, California: August, 1967; August, 1969; August, 1970; August, 1971.

Richmond, City of, Planning Division, "Data From the Standard Oil Company Richmond Refinery," Wind Rose, September 22, 1948.

Richmond, City of, "Wind Rose, University of California, Richmond Engineering Field Station," September 22, 1948.

U. S. Army, Corps of Engineer, San Francisco District, "Richmond Harbor, California, Navigation Study - Milestone 04, Checkpoint I Report", June 12, 1975.

U.C. BERKELEY LIBRARIES



C113908831

